Vol. LXX NOVEMBER, 1919 No. 5

ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

Edited by
LEWIS STEPHEN PILCHER, M.D., LL.D.
of New York

With the Collaboration of
SIR WILLIAM MACEWEN, M.D., LL.D. of Glasgow
SIR W. WATSON CHEYNE, C.B., F.R.S. of London

THE IMPORTANCE OF THE SPLEEN IN RESISTANCE TO INFECTION . . 513
Dudley H. Morris, M.D., and Frederick D. Bullock, M.D. . . . New York

LIFE EXPECTANCY OF PATIENTS FOLLOWING OPERATIONS FOR GASTRIC AND DUODENAL ULCER 522
Donald C. Balfour, M.D. . . . . Rochester

OPERATIVE TREATMENT OF PEPTIC ULCER, REMOVAL OF ULCER WITH GASTRO-ENTEROSTOMY, OR GASTRO-ENTEROSTOMY ALONE 526
John B. Deaver, M.D. . . . . Philadelphia

CHOLEDOCHO-ENTEROSTOMY AND POST-OPERATIVE DILATION OF THE BILE DUCTS 530
William Howard Barber, M.D. . . . . New York

THE CONDITION OF THE APPENDIX IN FIVE HUNDRED LAPAROTOMIES ON PATIENTS REPRESENTING NO SYMPTOMS OF APPENDICITIS 535
John T. Williams, M.D., and Robert Slater, M.D. . . . . Boston

LUNG ABSCESS 539
Nathan W. Green, M.D. . . . . New York

TREATMENT OF CHRONIC EMPYEMA 545
Martin B. Tinker, M.D. . . . . Ithaca
John E. Wattenberg, M.D. . . . . Kansas City

TREATMENT OF CHRONIC EMPYEMA 552
John E. Wattenberg, M.D. . . . . Kansas City

THE PATHOGENESIS AND TREATMENT OF LYMPHOSARCOMA AND HODGKIN'S GRANULOMA 561
Isaac Levin, M.D. . . . . New York

CONTINUED ON PAGE 2

J. B. LIPPINCOTT COMPANY, PUBLISHERS
MONTREAL PHILADELPHIA LONDON

Entered at the Post-Office at Philadelphia and admitted for transmission through the mails at second-class rates. Price, $6.00 a year. Copyright, 1919, by J. B. Lippincott Company, 227-231 South Sixth Street.

Stanolind
Reg. U. S. Pat. Off.
Surgical Wax

Alleviates Pain

When the wax film is laid on a denuded surface the patient is relieved of pain immediately.

Until after the healing process has started, Stanolind Surgical Wax should not remain on the wound longer than twenty-four hours.

Later the wound may be cleansed and redressed every forty-eight hours.

In removing the dressing, when that portion adhering to the uninjured skin has been loosened, the entire film may be rolled back without causing the least pain, or without injury to the granulations.

Stanolind Petrolatum

For Medicinal Use

In five grades to meet every requirement.

Superia White, Ivory White, Onyx, Topaz and Amber.

Stanolind Petrolatum is of such distinctive merit as to sustain the well-established reputation of the Standard Oil Company of Indiana as manufacturers of medicinal petroleum products.

You may subject Stanolind Petrolatum to the most rigid test and investigation—you will be convinced of its superior merit.

STANDARD OIL COMPANY

(Indiana)

Manufacturers of Medicinal Products from Petroleum

910 S. Michigan Avenue Chicago, U. S. A.

765

ANNALS *of* SURGERY

VOL. LXX NOVEMBER, 1919 No. 5

THE IMPORTANCE OF THE SPLEEN IN RESISTANCE TO INFECTION

BY DUDLEY H. MORRIS, M.D.
AND
FREDERICK D. BULLOCK, M.D.
OF NEW YORK, N. Y.

(From Columbia University, George Crocker Special Research Fund, F. C. Wood, M.D., Director)

ALTHOUGH there is a widespread impression that the spleen plays a part in resistance to infection and statements to this effect have found their way into many text-books, very little experimental evidence has been offered to support this view or to refute it. There exists a vast literature dealing directly or indirectly with the relation of the spleen to infectious processes, but most of the work which has been done is fragmentary, conflicting, and unconvincing. Far-reaching inferences have been drawn and laws deduced from a series of three or four animals. Complete autopsies are almost entirely wanting; cultures have not been standardized; racial and individual susceptibility to different bacteria has frequently been ignored; and, in addition, the normal mortality of laboratory animals is not sufficiently taken into account. It is assumed that the experiments are performed on normal animals, whereas the contrary is frequently the case; and the conflicting results obtained are often due to the fact that some of the animals are the victims of pathologic processes that have nothing to do with the experiment. It is a matter of common observation that nearly all the animals which are commonly used in experimental work are the carriers, not only of a host of parasites, but of a number of infections, epidemic and otherwise. The parasitic worms in dogs, of which there are a great many varieties; the pneumonia, septicæmia, and coccidiosis of rabbits; the paratyphoid fever and intestinal worms of mice, the chicken and hog cholera bacilli, which are pathogenic for widely different species of animals: all these are examples only too well known to require emphasis. Under these circumstances, it becomes self-evident that no experimental work can be entirely trustworthy which does not include the recognition and elimination of these outside sources of error.

Especially in experiments dealing with the effects of bacteria and their toxins is it necessary, by very careful and complete examinations, both gross and microscopical, to exclude a mortality due to chance infection; and, in addition, blood or tissue cultures should be made, to establish, if possible, the cause of death. This involves a tremendous amount of work, but is indispensable to accurate results and sound conclusions.

Of the work hitherto done on the relation of the spleen to resistance to infection the most convincing is that of Pfeiffer and Marx.[1] These authors, working on the formation of immune bodies in cholera, found that these substances were present in the spleen and bone-marrow in much greater quantity than elsewhere in the body. This condition persisted for months until finally the bacteriolytic content of the blood equalled that of the spleen. While removal of the spleen prior to the immunizing process did not prevent the formation of immunity, it was found that if the immunization was attempted before splenectomy, immunity failed subsequently to develop. These results of Pfeiffer and Marx for cholera have been confirmed by Wassermann [2] for typhoid, and by numerous other observers.

Much experimental work has been done to test the resistance of animals to infection following removal of the spleen. It is, of course, an observation of great antiquity that the operation of splenectomy is not followed by death. Indeed, one may live for years without suffering any apparent ill effects from the absence of the organ; but this does not settle the problem as to whether or not a splenectomized person can weather a critical illness. Nor do we know how long it takes or to what extent it is possible for the bone-marrow or the lymphatic system to compensate for the loss of the spleen. Among the experiments undertaken to clear up this question are the following:

Roger,[3] who injected rabbits intravenously with a virulent culture of anthrax, found that the splenectomized animals died sometimes before, sometimes after the controls. This result might be expected, since rabbits have little or no resistance to anthrax, and the splenectomy would probably not materially hasten the process.

Bardach [4] injected twenty-five splenectomized dogs with 1 c.c. of anthrax culture, and found that of these animals, normally resistant to anthrax, nineteen died. Only five of the twenty-five normal control animals died after a similar injection. In a second series of experiments, Bardach attempted to immunize rabbits with attenuated cultures of anthrax. Of thirty-five splenectomized animals, twenty-six died of anthrax. The controls showed a much lower mortality.

Tizzoni and Cattani [5] inoculated three groups of rabbits with tetanus cultures. Those vaccinated and not splenectomized resisted the inoculation; whereas those vaccinated fifteen days after splenectomy died in the same time as the unvaccinated animals.

On the other hand, other observers who tried similar experiments

failed to find any difference between splenectomized and normal animals. Kourlow [6] inoculated splenectomized rabbits intravenously with cultures of chicken cholera, anthrax, and Staphylococcus pyogenes, and found that the spleenless animals died sometimes before, sometimes after the controls.

Martinotti and Barbacci [7] injected splenectomized rabbits with anthrax cultures, but failed to note any difference between these and the controls.

Courmont and Duffau [8] injected rabbits with pyocyaneus, staphylococcus, and streptococcus, and likewise obtained conflicting results; they concluded that the kind of organism and especially the time after splenectomy were important in determining whether splenectomy made the animal more or less resistant to infection. In these experiments the conclusions in each case were drawn from the behavior of one animal and one control.

More recently, Hubbard [9] has published his results in a few experiments upon splenectomized guinea-pigs. But here again the numbers are too small to be of much value. While numerous other investigators [10] have studied the relation of the spleen to resistance to infection, it can not be said that any of them have furnished much positive proof.

The blood changes following splenectomy, which might throw some light on the question of the animal's power to resist infection, have been the subject of considerable research.[11] These changes in dogs after splenectomy may be summarized as follows:

1. Moderate secondary anæmia, lasting one or more months.

2. Leucocytosis, most marked twenty-four hours after operation, and lasting for several months.

3. Increase in the polymorphonuclears and lymphocytes, and decrease in the mononuclears and transitionals, followed later by the reverse.

4. Absence of eosinophiles from the third to the eleventh week, followed by pronounced eosinophilia.

5. Appearance of nuclear particles in red blood-cells and presence of normoblasts in the circulating blood.

On the whole, they can not be said to furnish positive evidence of an impaired ability on the part of the body to resist infection; but it seems possible that the anæmia and leucocytosis which are temporarily observed are an indication of increased susceptibility to infection and imperfect reaction against it.

There are certain observations which lend color to the view that the spleen bears a special relation to infections in general. The prompt formation of an acute splenic tumor in many severe systemic infections indicates that the spleen is extremely sensitive to bacterial invasion. Moreover, if the myeloid metaplasia so frequently met with in the spleens of those suffering from generalized infection [12] indicates an effort at increased production of new blood-cells, this activity might be considered as only part of the process of resistance to the bacterial invader.

Whether the spleen really does pour out new blood-cells in considerable quantity has been the subject of considerable discussion, and the question is yet far from settled; but there is strong evidence that blood-formation is one of the functions of the spleen.[13]

While the spleen has been fairly definitely shown to be an important, if not the chief organ for the formation of bactericidal substances, it has been denied that it is greatly concerned with the production of agglutinins, precipitins, or antitoxins. This subject is, however, still *sub judice*, and the recent work of Hektoen [14] points strongly to the spleen and other lymphatic tissues as being concerned in the production of lysins, agglutinins, opsonins, and precipitins. Most of the experiments done in this field depend upon the reactions of tissue extracts outside the body, and, therefore, do not closely approximate the actual conditions in the living organism.

In order to arrive at some definite conclusion as to the importance of the spleen in opposing infection, the following series of experiments was begun on a large scale in the hope of definitely settling the question whether or not the removal of the spleen lowered an animal's resistance.

For these experiments, white and brindle rats were chosen, because they could be obtained readily in sufficient quantity for tangible results, and because in these animals the operation of splenectomy is very simple and is rarely followed by any complications such as wound infection, hemorrhage, or hernia. Furthermore, rats are particularly insusceptible to nearly all the common pathogenic organisms and unlikely to develop complicating infections which would confuse the results. While the rat is prone to be infested with a number of parasitic worms, the principal mortality results from septicæmia caused by an organism of the typhoid group which is very similar in its behavior to that causing hog and chicken cholera. This organism, the bacillus of rat plague, which has probably been described by a number of observers under different names, was isolated by Issatchenko,[15] and shown to be responsible for the rat plague then existing in St. Petersburg. While this organism has by some [16] been regarded as identical with the Ratten bacillus, the B. Danysz, and the B. enteritidis (Gaertner), it is unlike the last in being non-pathogenic to rabbits and in the fact that its broth cultures do not yield a toxic filtrate. The toxicity of the cultures, moreover, is destroyed by heating to 70° C. In this respect, as well as in its morphological and cultural characteristics, it resembles closely the B. typhi murium of Loeffler,[17] but as the latter is not ordinarily pathogenic for white rats, it seems safer to refer to the one employed by us as the B. Issatchenko or the bacillus of rat plague.

The organism is a slender motile rod which varies greatly in length in individual cultures and also according to the media used; short forms predominate. It is gram-negative, and takes the polar stain; in unstained preparations the translucent centre and darker poles are very striking.

The surface colonies on agar are round or oval, grayish, translucent discs. Gelatin is not liquefied. The broth cultures show general turbidity and pellicle formation followed later by sediment. Growth on potato is slow and scant, but after forty-eight hours a thin grayish covering appears. Litmus milk is turned first red, then blue-red. Glucose, galactose, levulose, and mannite are fermented, but not lactose, saccharose, dextrin, or maltose. There is no indol production. Growth takes place on all ordinary media.

We have found the infection to be both endemic and epidemic in the rats of this laboratory, and to cause nine-tenths of the mortality among these animals. Its behavior has been very carefully studied, and because of its morphology and growth characteristics, as well as because of the very uniform pathological lesions which result from its inoculation into an animal, it can with reasonable certainty be identified as the cause of death. Its cultures can readily be standardized; and as it can easily be recovered from the heart's blood after death, the organism proved to be most suitable for our experiments. These were as follows:

Thirty-six apparently healthy young brindle rats, weighing from 50 to 100 grammes each, were splenectomized under ether anæsthesia. Great care was taken to guard against any operative complications, such as hemorrhage or infection, and the subsequent autopsies showed that none had occurred.

A similar number of control rats of like weight and breed were subjected to a laparotomy in which one testicle was removed. As the testicle is larger than the spleen and the blood-vessels entering it are about equal in size to the splenic vessels, its transabdominal removal furnishes a very fair basis of comparison as to the effect of the operative trauma alone upon the subsequent health of the animals.

Both sets of animals were found to be active and thriving on the day following the operation. They were then exposed to chance laboratory contagion and kept under observation for several months. Whenever an animal in either series died, an animal of the other group was killed, and both were completely autopsied. Microscopical sections were made from all important organs, and cultures were taken from the heart's blood and from the peritoneal cavity or lung.

It was then observed that the splenectomized animals almost invariably died before the controls, and that the death-rate among them was 80.5 per cent. as compared with 38.9 per cent. in the control rats. Necropsy showed the following lesions: Congestion and parenchymatous degeneration of nearly all the important organs, varying from injection of the vessels and slight cloudy swelling to focal necroses or extensive disintegration of the parenchyma. If the animal had survived long enough for a reparative process to set in, there was replacement of the degenerated areas by new-formed granulation tissue.

These changes, which are characteristic of the tissue injuries wrought

by the bacillus of rat plague and certain kindred organisms, may be summarized as follows:

1. Lungs: congestion; *lobular pneumonia;* lobar pneumonia.

2. Thymus: parenchymatous degeneration; *necrosis;* and *replacement of the organ by granulation tissue.*

3. Heart: *myocardial degeneration* (fatty, hyaline), associated often with an interstitial cellular infiltration.

4. Liver: congestion; cloudy swelling; fatty infiltration; *focal necrosis* or extensive degeneration of essential cells with accumulation of fat.

5. Kidney: congestion; *parenchymatous degeneration* with *focal necrosis;* glomerular and tubular nephritis.

6. Pancreas: œdema and degeneration of parenchyma.

7. Lymph-nodes and lymph-follicles of intestine: acute lymphadenitis and focal necrosis.

8. Spleen: acute splenic tumor with focal necrosis.

These changes were found nearly always in the animals that died spontaneously, whereas in those that were killed as controls they were generally absent.

The peritoneal cultures were uniformly negative; but the heart's blood of the animals that died showed, as a rule, the presence of an organism of the typhoid group, and usually this could be identified as the bacillus of rat plague. The cultures from the animals killed as controls quite regularly remained sterile.

While it is probable that in the presence of an epidemic all the rats were exposed to infection with the bacillus of rat plague, and the autopsy findings suggest that many developed it, we conclude from the results (1) that the splenectomized rats were more prone to contract the disease; and (2) that, having contracted it, they showed less resistance to its ravages. This was evidenced by the greater frequency of septicæmia, by the graver character of the lesions observed *post mortem,* and by the high and rapid mortality in the splenectomized animals.

Since the mortality in the splenectomized animals was over twice that in the orchidectomized, it is probable that the lowered resistance of the spleenless animals to chance infection by the bacillus of rat plague was due to the removal of the spleen.

In order to test this out more fully a second series was begun. Seventy-two brindle or white rats of about 50 to 100 grammes' weight were splenectomized, and a like number of control animals castrated by the abdominal route. In this series, both sets of animals were exposed to chance laboratory contagion, and a record of the mortality in each group was kept, none being killed. After two months the records were compared. In the orchidectomized group, 21 rats, or 29.2 per cent., had died. The organs of most of these showed the lesions characteristic of rat plague infection, and this organism was cultured from the heart's blood. This is about the same mortality as that prevailing among stock labora-

tory rats that have not undergone operation. In the splenectomized group, 61 rats, or 84.7 per cent., had died, and these likewise showed the lesions of rat plague infection. The heart's blood was positive for this organism in about 50 per cent.

The results in this group three weeks after operation were as follows: 36 of the splenectomized rats had died of the prevailing epidemic; while but 7 of the castrated controls had died. The mortality was thus five times as great in the splenectomized group as in the controls. In each group, septicæmia was demonstrated by blood cultures as the cause of death in a high percentage. The organism was almost invariably that described as responsible for the epidemic or one morphologically akin.

These results showed that under ordinary laboratory conditions splenectomized rats were far less resistant to a common infection than those animals which had not been deprived of their spleens. The spleen then must in some way help to protect the animals against infection, since removal of another organ of equal size and weight by a similar operative procedure caused no impairment of the defensive mechanism.

To render the experiment still more conclusive, in a third series, two groups of young rats, comprising 88 animals in each, immediately following splenectomy in the one group and orchidectomy in the other, were injected subcutaneously with a sublethal dose of a broth culture of the bacillus of rat plague. The effect of this should be to hasten the death of those animals that were susceptible to rat plague, whereas those that had a certain amount of natural immunity would remain in good health and acquire an added resistance.

It was found that 1 c.c. of a mixed three- and five-day broth culture of the bacillus of rat plague was the least dose that could be relied upon to kill rats of 50 to 100 grammes' weight in five to ten days. In this experiment, therefore, 0.2 c.c. of a mixed three- and five-day broth culture was used. This dose produced in the castrated rats 22.7 per cent. of deaths, which is but little or no increase over the normal death-rate of non-operated, uninjected animals. In the splenectomized rats, however, the death-rate was enormous, amounting to 87.5 per cent. The date of death was likewise hastened, so that the majority of these animals died on an average of nine days following splenectomy. All showed the lesions characteristic of rat plague infection, and the organism was obtained in pure culture from the heart's blood in 82.9 per cent. of the cases, showing that death was undoubtedly due to bacteræmia caused by the inoculated organism.

In order to ascertain whether older rats were affected by splenectomy to the same degree, a fourth series was begun, in which 24 rats weighing from 200 to 250 grammes were splenectomized and a corresponding number castrated. Following operation each set received a subcutaneous inoculation of 0.6 c.c. of the mixed three- and five-day cultures of rat plague bacillus. The results in this series corresponded in every respect with

those in the previous lot, but were even more striking. Of the 24 adult rats which were splenectomized and injected with the culture of rat plague bacillus, 21, or 87.5 per cent., died within twelve days, and positive blood cultures were obtained in 90.5 per cent. Of the 24 castrated animals, however, only 3, or 12.5 per cent., died in the two months following operation. These all gave positive blood cultures. It will thus be seen that in this series the death-rate among the splenectomized animals was over seven times that in the orchidectomized group.

CONCLUSIONS

These results show in a very definite manner that while these animals may get along fairly well without the spleen in the absence of any infection, the reverse is the case when the organism is put to the strain of resisting acute bacterial invasion. Under the circumstances, we must infer that the spleen normally aids tremendously in resisting infectious processes in rats, and that its removal temporarily robs the body of its resistance until such a time, at least, as compensatory processes will have had a chance to reëstablish this.

The surgical bearing of these results is obvious. If, as we may reasonably infer, the physiological processes of mammals are similar, it is not improbable that the human body deprived of its spleen shows a similar increased susceptibility to infection. Bearing this in mind, some of the fatalities following splenectomy, especially where death was attributed to infection, may find a ready explanation and tend to increase our caution in the removal of this organ.

REFERENCES

[1] Pfeiffer and Marx: Ztschr. f. Hyg., 1898, xxvii, 272.
[2] Wassermann: Berl. klin. Wchnschr., 1898, x, 209.
[3] Roger: Gaz. hebd. de méd., 1893, xiii, 146.
[4] Bardach: Ann. de l'Inst. Pasteur, 1891, iii, 577.
[5] Tizzoni and Cattani: Centralbl. f. Bakteriol., 1892, xi, 325.
[6] Kourlow: Arch. f. Hyg., 1889, ix, 450.
[7] Martinotti and Barbacci: Centralbl. f. allg. Path., 1890, i, 49; Fortschr. d. Med., 1891, ix, 371.
[8] Courmont and Duffau: Compt. rend. Soc. de biol., 1896, Series x, iii, 604; ibid., 1897, Series x, iv, 1089.
[9] Hubbard: Boston Med. and Surg. Jour., 1909, clx, 743; Bull. Harvard Med. Sch., 1909, vi, 125.
[10] Biagi, N.: Arch. et atti d. soc. Ital. di Chir., 1906, xix, 76; Blumreich, L., and Jacoby: Berl. klin. Wchnschr., 1897, xxxiv, 444; Montnori, A, Riforma med., 1893, ix, 472; Lyonnet: Lyon méd., 1898, lxxxix, 341; Noguchi, N., Berl. klin. Wchnschr., 1912, xlix, 1839; Wolff, München. med. Wchnschr., 1912, lix, 1912; Dumonlin; Contribution a l'étude du role de la rate dans les infections, Lyons, 1904.
[11] Musser, J. H.: Arch. Int. Med., 1912, ix, 592; Vulpins, O.: Beitr. z. klin. Chir., 1894, xi, 633; Meyer, A.: Centralbl. f. d. Grenzgeb. d. Med. u. Chir., 1914, xviii, 41; Wolferth, C. C.: Arch. Int. Med., 1917, xix, 105; Guilbert and Quinter: Arch. Int.

Med., 1917, xix, 140; Pearce and collaborators: Jour. Exper. Med., 1912–16, numerous papers; Pearce, Krumbhaar, and Frazier: The Spleen and Anæmia, Philadelphia, 1918.

[13] Meyer, E., and Heineke, A.: Verhandl. d. deutsch. path. Gesellsch., 1906, ix, 224; Deutsch Arch. f. klin. Med., 1907, lxxxviii, 435; Morris, R. S.: Bull. Johns Hopkins Hosp., 1907, xviii, 200; Jolly, J., and Rossello, H.: Compt. rend. Soc. de biol., 1909, lxvi, 40; Schridde, Centralbl. f. allg. Path. u. path. Anat., 1908, xix, 865.

[14] Morris, D. H.: Jour. Exper. Med., 1914, xx, 379; Loewit, M.: Folia hæmat., 1907, iv, 473; von Ebner: Köllikers Handbuch der Gewebslehre, 1902, iii, 276.

[15] Hektoen: Jour. Infect. Dis., 1918, xxii, 28.

[16] Issatchenko: Centralbl. f. Bakteriol., 1898, xxiii, 873.

[17] Uhlenhuth, P., and Hülener, E.: Kolle and Wassermann, Handbuch d. path. mikroorganismen, 2d ed., Jena, 1913, iii, 1114.

[18] Bongert, J.: Kolle and Wassermann, Handbuch d. path. mikroorganismen, 2d ed., Jena, 1913, vi, 188.

LIFE EXPECTANCY OF PATIENTS FOLLOWING OPERATIONS FOR GASTRIC AND DUODENAL ULCER *

By Donald C. Balfour, M.D.
of Rochester, Minn.

Efficiency in the surgical treatment of many diseases has been measured in the past by operative mortality, and by the permanency of relief which the patient has secured by operation. With the gradual development of surgical technic, and our increasing knowledge of surgical indications, operative mortality and relief of symptoms have been so favorably influenced that they have now in many fields apparently reached their limit of development. It is also true, however, that in all diseases life expectancy can be said to be the major consideration with the patient, and yet this consideration of preëminent interest to the patient has not received the study which it deserves, particularly in those diseases in which operation is conducted primarily for the relief of symptoms.

Diseases of the gastro-intestinal tract stand out most prominently as illustrations of this fact. With the advent of operations such as gastro-enterostomy, in which the normal functioning of the gastro-intestinal tract is changed, the question whether such procedures have influenced the length of life of the given individual becomes one of great importance in connection with the surgical treatment of benign lesions of the stomach and duodenum.

During the several years past we have been repeatedly asked by insurance companies whether a given patient, whom we have operated on for gastric or duodenal ulcer, should be accepted as a good insurance risk. We have had impressions as to the advisability of accepting such risks, but until recently we have never had any actual proof of life expectancy after operations have been carried out on such persons as compared with a group of persons in the general population of similar age and sex.

As we have always realized the importance of securing positive information along these lines we accepted with readiness the proposal of the Actuarial Society of America that they should study the records at the Mayo Clinic and by their own methods carry out some follow-up investigations with regard to the length of life which may be anticipated in patients operated on for gastric and duodenal ulcer. This association has recently compiled and published the statistics, and although, in the main, they agree with information which we have been able to secure for ourselves, yet their methods of investigation, their system of accurate tabulation, and above all, their unbiased interpretation of such information, add unusual interest and value to the figures which I present.

Unfortunately there is no basis on which the results of the present investigation of operated gastric and duodenal ulcers can be compared

* Read before the American Surgical Association, June 17, 1919.

with the results in non-operated cases. Not only are no statistics available as to life expectancy in non-operated cases of gastric and duodenal ulcer, but accurate statistics in this group will probably never be entirely possible, because the uncertainties in diagnosis discount more or less the dependability of such figures. On the other hand, surgical statistics are based on proved lesions, and on lesions in which medical treatment has failed. If proved statistics of non-operative cases become available, the surgeon will welcome the opportunity of establishing the fact that surgical measures of treatment are the most efficient from every standpoint.

The investigation carried out by the Actuarial Society of America was under the direction of Mr. Arthur Hunter, Chief Actuary of the New York Life Insurance Company. It is first interesting to note the success of the methods employed by this society for tracing cases. Of a series of 2431 patients operated on for gastric and duodenal ulcer in the Clinic between 1906 and 1915, all but 108 were traced, a percentage record which I am sure has never before been approached.

The figures first show that the operative mortality from all causes[1] in 545 cases of gastric ulcers in which operation was done during this period was 4.5 per cent., while in 1684 cases of duodenal ulcer the operative mortality from all causes was 2 per cent. Gastric ulcer carries, therefore, twice the operative risk of duodenal ulcer.

The Association's investigations of the mortality in the years after operation show the following facts:

Gastric Ulcer.—Five hundred twenty-one patients were under observation on the average of 3.6 years, and in that time 88 (17 per cent.) died from all causes.

Duodenal Ulcer.—One thousand six hundred fifty-one patients were under observation on the average of 3.4 years, and in that time 85 (approximately 5 per cent.) died from all causes.

Gastric and Duodenal Ulcer.—Ninety-one patients were under observation on the average of 3.8 years, and in that time 9 (10 per cent.) died.

Mr. Hunter's first observations on these statistics are most interesting. I quote verbatim: "The fact that 17 per cent. of those operated on for gastric ulcer have died within an average period of observation of 3.6 years, and the fact that 5 per cent. of those operated on for duodenal ulcer have died within an average period of observation of 3.4 years, are in themselves significant. While we cannot tell how many lives have been saved by reason of operation for duodenal ulcer, it may safely be stated that the survival for three and a half years after the operation of 95 per cent. is a high tribute to surgery. With such a serious condition as gastric ulcer, a death rate in three and a half years of 17 per cent. of those operated on appears to be low. While I cannot prove my statement, I believe that a much larger proportion of persons would have died but for the operation, and that many years of life in the aggregate were saved through surgical treatment."

[1] The cause of death has not been considered in this study.

The chief point of importance in these statistics, however, is gained by comparing the mortality figures of a group of patients subjected to operation for gastric and duodenal ulcer with a group of the general population corresponding in age and sex:

TABLE I

GASTRIC ULCER

Deaths in group of 521 persons operated on:

Following the Operation	Deaths
First year	36
Second year	21
Third year	11
Fourth year	7
Fifth year	7
Sixth year and subsequent	6
	88

General population group of 521 persons with like distribution as to age and sex observed during the same period of time:

Observation	Deaths
First year	8.2
Second year	6.5
Third year	4.9
Fourth year	4.1
Fifth year	3.0
Sixth year and subsequent	5.6
	32.3

It will be noted in Table I that the number of deaths in the first year following operation was about four and one-third times the deaths in a like group in the general population; in the second year this number was three and one-fourth times that of the general population, and in the later years it was still less. With an average period of observation, therefore, of only three and one-third years, the deaths in the year following operation, when the mortality is highest, have much greater weight in the total than if the observations were conducted for a longer period.

In duodenal ulcer a similar comparison shows most instructive findings:

TABLE II

DUODENAL ULCER

Deaths in group of 1651 persons operated on:

Following Operation	Deaths
First year	22
Second year	20
Third year	9
Fourth year	10
Fifth year	11
Sixth year and subsequent	13
	85

General population group of 1651 persons with like distribution as to age and sex, observed during the same period of time:

Observation	Deaths
First year	24.0
Second year	18.6
Third year	14.3
Fourth year	11.2
Fifth year	8.3
Sixth year and subsequent	16.7
	93.1

Here we have the rather astounding fact that in the first two years following operation for duodenal ulcer the mortality is only that of the general population group, and that after the second year the mortality is actually less than in the general population group. These statistics illustrate very strikingly the fact which always has been recognized by surgeons: namely, that gastric ulcer is a much more serious condition than duodenal ulcer, not only from an operative standpoint, but from a standpoint of after-results, and that the patient with a gastric ulcer shows, as a rule, much more evidence of impaired general health than the patient with duodenal ulcer.

SUMMARY

1. The percentage of operative deaths in the hospital following operation for gastric ulcer was fully twice that following duodenal ulcer, but the percentage in both cases was very low considering the seriousness of the condition.

2. The mortality during the three years following the operation among persons operated on for gastric ulcer was three times as high as that among persons operated on for duodenal ulcer.

3. The mortality among persons operated on for gastric ulcer decreases relatively after operation, but the data are not sufficient to determine the number of years which must elapse before the death rate is similar to that of the general population.

4. The mortality among those operated on for duodenal ulcer in this series was less than that among the general population.

5. The average age at time of operation of those operated on for gastric ulcer was 47 for men, and 43 for women; the average age of those operated on for duodenal ulcer was 44 and 42, respectively.

OPERATIVE TREATMENT OF PEPTIC ULCER; REMOVAL OF ULCER WITH GASTRO-ENTEROSTOMY, OR GASTRO-ENTEROSTOMY ALONE*

By John B. Deaver, M.D.
of Philadelphia, Pa.

There are no hard and fast rules in abdominal surgery. Each case that presents itself must be treated along the lines that give promise of the best results. Therefore the answer to the subject I have chosen to discuss would be: it depends. But in order to be a little more definite I had better say, that other things being equal excision of the ulcer, or resection followed by gastro-enterostomy, is the procedure of choice. However, there is a large *but* that looms up to modify this statement. Other things rarely are equal, and the powers, whichever they may be, that afflict humankind with peptic ulcers do not always place them where they can without great difficulty be removed; or, as sometimes happens, in perforating ulcers the surgeon is spared the trouble of removing them.

That others regard the excision of the ulcer as the most desirable thing is evidenced by the work of Balfour at the Mayo Clinic, where with the ingenuity that characterizes the methods of that institution the cautery has been requisitioned for the treatment of peptic ulcers and has proved of particular value in treating those that are not easily accessible to the knife. The procedure, as described by Balfour, depends not only on heat, but mainly on complete perforation with the cautery as an essential to the success of the method, inasmuch as clinical experience has shown that spontaneous perforation of gastric ulcer, if complete, usually cures the ulcer and also the patient. Combined with gastro-enterostomy the method has given excellent immediate and remote results, particularly with regard to gastric motility.

I cannot entirely agree with Balfour's implication that spontaneous perforation if complete cures the patient. It has been my experience to observe recurrence of perforation in two instances. In one of these the patient, after being operated for duodenal perforated ulcer, returned later with a second duodenal perforation, and again some time afterwards with a gastric perforated ulcer.

It is claimed by many that gastro-enterostomy of itself is a curative measure, and so it is for a time. But the ulcer, if it is allowed to remain, may or may not heal, and experience with the "may not" has shown that in order to insure a positive result the ulcer must be removed.

What does gastro-enterostomy without resection of the ulcer do? It makes an indirect attack on the ulcer, diminishes the acidity of the gastric

*Read before the American Surgical Association, June 17, 1919.

secretion by neutralization with the alkaline juices of the intestines and the pancreas; thus reducing the various distressing symptoms, especially pylorospasm, that accompany peptic ulcer. If the stoma is large enough and properly placed it also obviates the stagnation of the gastric contents and hastens the evacuation time of the stomach which often occurs in less than normal time; the irritating action of the food and the digestive secretions is then removed and the ulcer given a chance to heal. You will notice that there are two *ifs* which vitally affect the usefulness of the operation. I believe it is generally conceded that the food will seek its natural outlet wherever there is provision for it to do so, and that in the presence of any degree of patency of the pylorus after gastro-enterostomy some of the food passes through it. Cannon and Blake, on the basis of their fluoroscopic experimental studies, have maintained that the new opening probably closes in the course of time if the pylorus be patent; they also observe that the food as well as fluids circulate through the pylorus and duodenum and back through the anastomosis to the stomach without causing a vicious circle. It has been my experience that a gastro-enterostomy properly made and properly placed, with a patulous pylorus, does not close. I have repeatedly observed this in many secondary operations, which I have made, as well as by the barium or bismuth meal in a fluoroscopic examination. With the stomach empty the pylorus is the lowest part of the organ, and at this point intragastric pressure is three to four times more than at the cardia, so that the artificial opening must be made as large and as near the pylorus as possible. Hartmann, who has probably made the most comprehensive study of the question of the functioning of the gastro-enterostomy opening, shows experimentally that the physiological process with a permeable pylorus depends on the position of the stoma. If it is near the pylorus the greater part, but not all of the chyme, passes through the new opening, a little passing through the pylorus, and when the opening is made at a distance from the pylorus near the cardiac end of the stomach almost all the chyme passes through the pylorus.

We have therefore these two important items to consider when doing gastro-enterostomy without excision of the ulcer.

What does resection plus gastro-enterostomy do? I cannot think that anyone, unless he is dealing with a very small ulcer at a most favorable location, would simply remove an ulcer and fail to follow it up at once with the anastomosing operation unless he wants to have two operations to do instead of one. The radical operation presents the same advantages as the less complete one with the added benefit of a direct attack on the ulcer, and thus at one stroke reduces if not removes the chance of carcinomatous degeneration (in gastric ulcer), of perforation and hemorrhage, except in case of overlooked multiple ulcers, which are rare.

Perforation of peptic ulcer is by no means so rare as to be a negligible quantity to be reckoned with in the treatment of chronic ulcers. In the past year, January 1, 1918, to January 1, 1919, it occurred in about 5.2 per cent. of my cases. Every medical man of large experience, I am sure, has had

the unpleasant opportunity of observing perforation occur while a patient has been in the medical ward of a hospital or in his own home undergoing medical treatment for what is essentially a surgical condition. The proper time for medical treatment for the results of chronic indurated peptic ulcer is not before but after the operation (if treatment is then still needed). For with the removal of the ulcer or with its exclusion from the corroding action of the digestive juice the damaged mucosa has a better chance of responding to treatment and a better chance of complete cure.

Carcinomatous degeneration of gastric ulcer, in spite of widely divergent statistics on the matter, is a decided menace and one that cannot be ignored.

The excision of a chronic ulcer or the radical removal of the ulcerous site may be attended with a somewhat greater mortality in the hands of some, for probably nowhere does the personal equation of the operator enter more than in the operative treatment of peptic ulcers. The radical operation doubtless presents greater difficulties, which experience can in a measure overcome but which early operation can materially reduce. It is the difficulty of transgastric resection, for example, for a chronic ulcer at the lesser curvature that leads many a surgeon to content himself with a gastro-enterostomy, especially when the condition is of long standing and has led to hour-glass contraction of the stomach, and extensive adhesions involving the pancreas, the gall-bladder and the intestine. But he cannot expect the same satisfactory end-results as from resection. It is indeed remarkable how well resection of large portions of the stomach is borne even by under-nourished and emaciated individuals, and how gratifying are the end-results of the operation.

There are, of course, circumstances when it is expedient to omit the gastro-intestinal anastomosis. As, for example, in ulcers distant to the pylorus with very little exudative induration. Simple excision of such an ulcer may suffice. This also applies to saddle-back ulcers and those situated on the lesser curvature toward the cardia, for which circular resection is the indicated operation. It has been my practice for a number of years not to follow circular resection with a gastro-enterostomy. But I have on two occasions been obliged to do a posterior gastro-enterostomy as a secondary operation after circular resection; since which time I am becoming convinced of the advantage of making the anastomosis at the primary operation.

For perforation of a duodenal ulcer I find it best after closing the perforation to plicate the duodenum and fortify the area by covering it over with the gastro-colic and gastro-hepatic omentum, completing the operation with a posterior gastro-enterostomy. This I believe is being more and more recognized as the proper procedure for acute perforating peptic ulcer. The two-stage operation has lost any favor that in the early days of gastric surgery it may have enjoyed.

In addition, I have also made it a practice, in recent years, to remove the appendix, and if necessary the gall-bladder at the same operation. Since 1915, up to January, 1919, I have treated 18 perforating peptic ulcers,

and in fourteen of these appendectomy, and in two, in addition to the appendectomy, cholecystectomy, formed part of the operation.

It may not be out of place to record the total number of perforations I have thus far treated. Up to January first, 1919, these have numbered 56 operations with two deaths. One death occurred twenty-two years ago and the other during the past year; thus making fifty-four consecutive operations with one hundred per cent. recoveries. In all but two of the entire series closure of the perforation followed by gastro-enterostomy was the method used.

CHOLEDOCHO-ENTEROSTOMY AND POSTOPERATIVE DILATION OF THE BILE-DUCTS

AN EXPERIMENTAL STUDY

By William Howard Barber, M.D.
of New York, N. Y.
Assistant Surgeon, Bellevue Hospital

(From the Department of Surgery, New York University and Bellevue Hospital Medical College)

Suture operations are quite often undertaken upon the common bile-duct in human surgery because the dilation of pathologic ducts makes them practicable. There are conceivable emergencies in which one may be forced to unite a small-sized common or hepatic duct to a loop of intestine or to the stomach and in which an oblique anchorage method may be helpful.

According to Baudouin, the first apparent attempt to perform choledochoenterostomy belongs to Riedel. Riedel, in 1888, endeavored to close a choledochostomy by suturing the bile-duct to the intestine. In 1890 Kocher failed to overcome a bilioduodenal fistula by a plastic operation upon the end of the bile-duct. In the following year, the first successful choledocho-enterostomy was carried out by Sprengel in a woman upon whom he had first done a cholecystectomy.[1] Guerry [2] has recently reported four symptomatic cures out of seven direct anastomoses. Mayo's [3] studies and successful case, published in 1905, emphasized the possibilities of end-to-end common duct and of end-to-side bilioduodenal union. Foreign substances have been introduced by Horsley,[4] Lewis,[5] Davis,[6] and others in efforts to abridge the gaps between the intact ends of partially destroyed bile-ducts. To this end, veins, fascia, and the appendix have been proposed but have not met with promising success. Sullivan's [6] suggestion of the use of the rubber tube has probably met with the most favor in this respect. At the present time, the indications appear to be for direct anastomosis when possible, and for indirect union by means of a rubber tube, as proposed by Sullivan and developed by Mayo, when necessary.

Any procedure to reunite a partially destroyed bile passage is made difficult by the inaccessibility of the operative field and by the large numbers of adhesions. A destruction of the common duct where the gall-bladder is absent or, for other reasons, unavailable for cholecystenterostomy impels the prosecution of some form of choledocho-enterostomy. In isolated instances, hepatico-enterostomy has been tried in spite of the dangers of liver abscess and of the difficulties of suturing gut to liver. On one occasion, Stewart [7] opened the duodenum and sutured it about the portal fissure in the hope that bile would eventually find its

way into the intestine. Tumor, calculus, or stricture may seriously interfere with the entrance of bile into the intestine. A duct may be divided or resected intentionally or accidentally at operation or it may be severed in a gunshot wound * by a bullet passing through the abdomen. The frequency of these causes of duct injury, in which choledocho-enterostomy may have to be resorted to, is well shown in Mayo's statistics of 159 common duct operations out of 1100 operations upon the liver and bile passages with complete loss of continuity of the common duct in 7. Of these, 5 were severed purposely during resection for carcinoma, 1 was unintentional, and 1 followed extensive operation for gall-stone disease.[8]

The following experiments are based in part upon experience in ureterocolostomy and in part upon the reports of others on bilioenteric anastomosis. As may be seen from the illustrations, the ligated bile-duct is drawn through the submucosa of a mobilized loop of small intestine or stomach, into the lumen of the same, and left fixed by the ligature in the exit needle-puncture opening. The end of the duct within the lumen of the bowel and below the ligature may be incised to provide for the immediate escape of bile, or, apparently, this step may be omitted with impunity, for, under the conditions of the experiment, bile may not enter the distal part of the transposed duct within two days, and the duct ends are found free in three days. Ninety per cent. of the animals represented had transplantations without this provision for spontaneous bile drainage. It is important not to disturb the terminal fascial connections of the duct any more than is absolutely essential. As in the ureteroenteric transplantations, the operative technic is simple and free from local infections but subject to the dangers of bile-duct dilation and ascending biliary infection.

Autopsies performed at various times during the postoperative life of these animals disclose many interesting findings. Ascending infection of the liver unfortunately has not been excluded and may have caused the death of certain of the apparently successful animals. In those instances in which the bladders were dilated, the livers, too, were deeply congested. In all the experiments, the ducts are found dilated, no matter at what time examined. At the end of the second day, the intramural segment is remarkably firm, due, apparently, to the fascial connections outside the bowel, to the exudative and fibrinous agglutination of the omenta, liver, and anastomotic loop, and to the enlargement of the intraintestinal end. The ligated end early retracts within the lumen, becomes swollen and congested, is free from the ligature in about three days, and ultimately disappears altogether. There is no evidence of persistent irritation about the new opening, which is beyond detection excepting at such times as bile is seen to come from it. The needle punctures and ligature-suture are amply protected by exudative material and scar tissue. The mucosa

* One gunshot wound of the common duct came under the department of surgery and was operated upon by Cramp during the past year.

of the intestine is continuous with the lining membrane of the bile-duct in most of the transplants and is interrupted in some, but not all, of the badly obstructed animals (Fig. 8). In the great majority of the dogs, the bile-duct, anastomosis, and the anastomotic intestinal loop are free from gross and microscopical evidence of disease aside from the biliary dilation which, to some extent, is common to all.

This dilation appears in the ureteral transplants [9] as it does in these animals after gall-duct transplantations and is evidently of nervous origin. In studying the relation of trauma to the neuromuscular function of the ureter, it was shown that the regular contractile wave in the dog's ureter recurred at nine-second intervals, but that when the nervous connections in the wall were impaired this peristaltic wave dropped off to twenty-five and sixty-nine second intervals, respectively, according to the degree of ureteral trauma. In many of these animals with known disturbed ureteral nerve connections, hydroureter and hydronephrosis developed. The relation of these dilations to possible nervous causes has recently been emphasized by Braasch.[10] In respect to the bile-duct, peristalsis, as far as I am aware, has not been observed and can not be studied in relation to trauma, but dilation certainly does follow division and transplantation. The bilioduodenal sphincter (sphincter of Oddi), like the ureterovesical "valve," stands as a barrier between open and closed systems against harmful pressure changes and ascending infection. These functions are well illustrated in Archibald's [11] excellent work on the biliary system. The direct nervous connections of this sphincter with the bile passages on the one hand and with the duodenum on the other are destroyed in division of the common duct. This interference with the neuromusculature of the duct and the loss of the "valve" probably unite to cause that apparently harmless biliary dilation occurring in all transplantations.

The present series comprise twenty animals, fourteen of which are successes barring the dilation above described and the possibilities of ultimate ascending infection of the liver, and six are partial or complete failures due to harmful compression of the intramural segments of the transposed bile-ducts. Four of these failures occur in the thick-walled stomach and two in the duodenum. In the relatively thin-walled jejunum the stomata are the most patent.

The following conclusions suggest themselves:

1. A severed bile-duct too small for sutures but long enough for direct choledocho-enterostomy may be reunited to the upper small intestine or the stomach by anchoring it obliquely within the wall of the intestine or the stomach.

2. Of twenty animals, eighteen, with temporarily obstructed ducts, developed patent functionating anastomoses in 72 per cent., and two with provision for spontaneous drainage. Of these latter, one animal has had a perfectly functionating anastomosis for four months.

FIG. 1.—This represents the first stage in bilioenteric anastomosis. The common bile-duct has been divided distal to a ligature with the ends left long, as indicated. It is apparently not necessary to ligate the duodenal end of the divided duct, for in no instance has leakage been found to have occurred from the united stump. A loop of small gut is brought up into the wound and in the vicinity of the free end of the duct.

FIG. 2.—A straight, fairly large-sized needle is attached to an end of the ligature and is run through the intestinal wall for a distance of 1.5 cm. The needle and duct are made to enter the lumen of the bowel and, immediately, to emerge perpendicularly. The trailing end of the ligature is recovered and held.

FIG. 3.—This exposed and ligated end of the bile-duct is fixed in the exit from the bowel by a simple anchorage suture. The original ligature is utilized for this suture, as indicated.

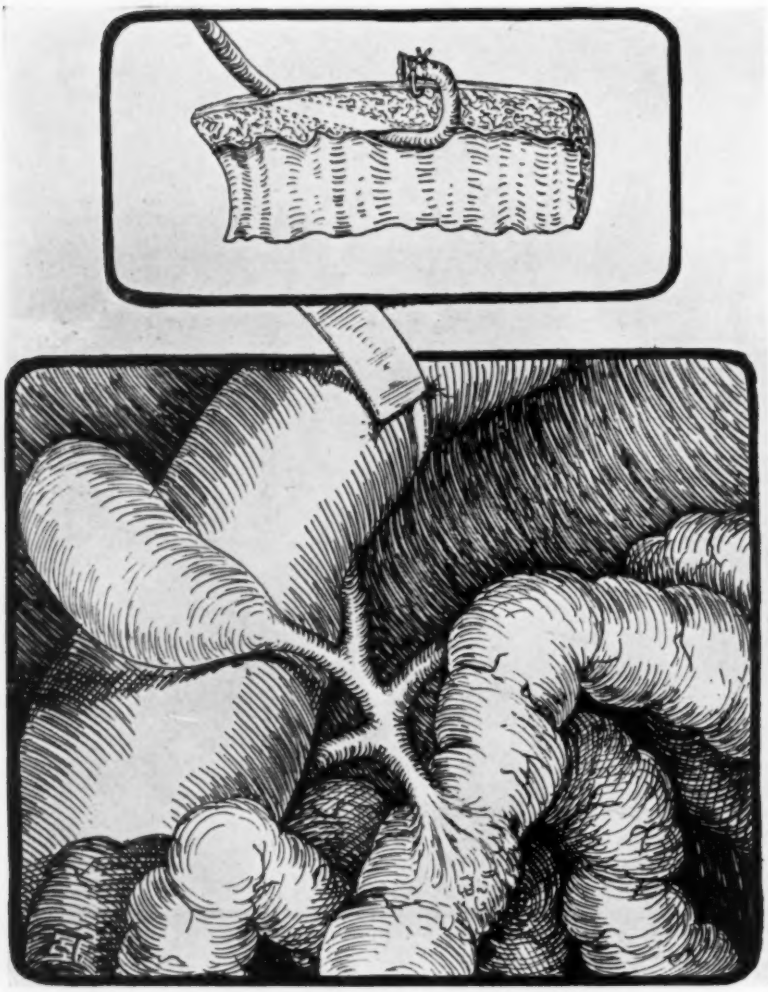


FIG. 4.—This represents an after-result and is taken at random from one of the "intact" animals. Note particularly the degree of gall-duct dilation. The insert above shows the relationship of bile-duct to intestinal wall and to lumen of bowel immediately after operation. Retraction probably always occurs, making leakage at exit impossible.

FIG. 5.—This is a photograph of a similar animal after euthanasia. Note loop of intestine opened up and duct stoma. This opening is free from evidence of irritation and can be discerned only by watching for the appearance of bile during pressure over bladder. Note relative sizes of duct and bladder.

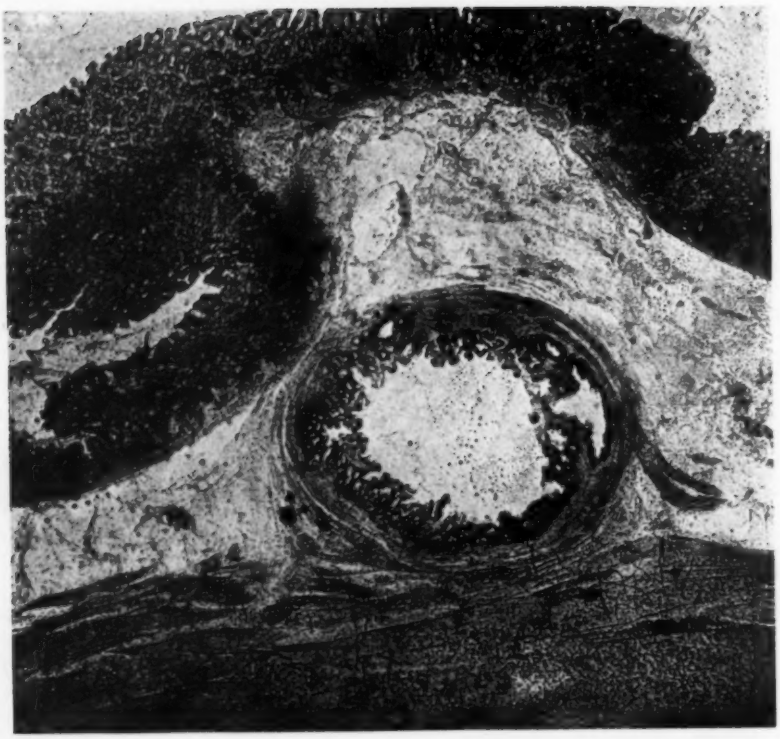


FIG. 6.—Microphotograph of a cross-section of an "intact" bilio-enteric anastomosis. Note duct lying in submucosa of intestinal wall. Note size of duct lumen and integrity of duct wall.

FIG. 7.—Microphotograph of a longitudinal section of a successful bilio-enteric anastomosis. Note relative sizes of intramural and extramural bile-duct, transition of lining epithelium, and integrity of duct wall.

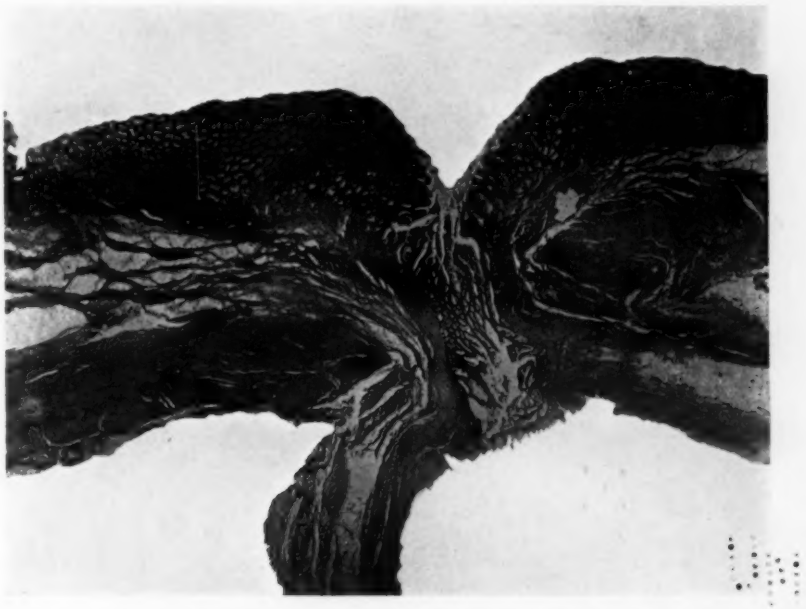


FIG. 8.—Microphotograph of a longitudinal section of an unsuccessful bilio-enteric anastomosis. Note marked dilation of extramural duct as compared with the intramural segment, diminished size of the intestinal portion, and beginning disintegration of the bile-duct, presumably from increased pressure.

3. A certain degree of dilation due to the inevitable interruption of the nervous connections during reconstruction of the bile-duct is not incompatible with life. Harmful dilation is associated with retraction of the transposed end, obstructive intramural scar, and deficient epithelialization.

4. The above technic reduces to a minimum the adhesion-forming traumata, and the factors in it tending to prevent the retraction and obstruction of the bile-duct are: (1) Proper mobilization of the anastomotic intestinal loop, (2) the oblique course of the intramural segment, (3) possibly the dilation of the intraintestinal end, and (4) anchorage of the bile-duct with due allowance for retraction.

SERIES NO. 1. EXPERIMENTAL CHOLEDOCHOGASTROSTOMY

Serial No.	Exp. No.	Postop. Life in days	Anatomical result: Gross and microscopic		Physiologic
1	4	23	Retraction; obstruction	.....	No bile on pressure.
2	11	32	Retraction; obstruction	.....	No bile on pressure.
3	18	17	Intact.....	Continuous layer of epithelium	Bile on pressure.
4	20	24	Partial retraction; obstruction	.....	Bile on plus pressure.
5	33a	10	Intramural stenosis	Obliterative inflammation	Bile on plus pressure.
6	28	44	Intact.....	Continuous layer of epithelium	Bile on pressure.
7	42	35	Intact.....	Continuous layer of epithelium	Bile on pressure.
8	69	59	Intact.....	.....	Bile on pressure.
9	33	99	Intact.....	.....	Bile on pressure.

The duration of life represented in Series 1, 2, and 3 does not give the number of days the animals could have lived; for in many instances the experiments were terminated by euthanasia.

SERIES NO. 2. EXPERIMENTAL CHOLEDOCHODUODENOSTOMY.

Serial No.	Exp. No.	Postop. Life in days	Anatomical result: Gross and microscopic		Physiologic
1	12	38	Intact.....	Continuous layer of epithelium	Bile on pressure.
2	1	49	Intact.....	.....	Bile on pressure.
3	43	25	Intact.....	Continuous layer of epithelium	Bile on pressure.
4	35	42	Intact.....	Continuous layer of epithelium	Bile flows spontaneously.
5	27	68	Intact.....	Continuous layer of epithelium	Bile on pressure.
6	32	60	Retraction; obstruction	.....	No bile on pressure.
7	41	41	Retraction; obstruction	.....	No bile on pressure.
8	94	120	Intact.....	Continuous layer of epithelium	Bile flows spontaneously.

SERIES No. 3. EXPERIMENTAL CHOLEDOCHOJEJUNOSTOMY

Serial No.	Exp. No.	Postop. Life in days.	Anatomical result: Gross and microscopic		Physiologic
1	40	19	Intact.....	Continuous layer of epithelium	Bile flows spontaneously.
2	62	?	Intact.....	.....	Bile on pressure.
3	70	17	Intact.....	.....	Bile flows spontaneously.

REFERENCES

[1] Baudouin, M.: Les Operations Nouvelles sur les Voies Billiaires, Paris, 1897, pp. 129–144.

[2] Guerry, LeGrand: Jour. A. M. A., Oct. 14, 1918, pp. 1194, 1195.

[3] Mayo, W. J.: ANN. SURG., 1905, vol. xlii, pp. 90–95; Collected Papers, 1915, p. 266.

[4] Horsley, J. S.: Jour. A. M. A., vol. lxxi, pp. 1189–1194.

[5] Walton, A. J.: Surg., Gyn., Obst., vol. xxi, p. 269.

[6] Sullivan, A. J.: Jour. A. M. A., 1912.

[7] Stewart, G. D.: Personal communication.

[8] Mayo, W. J.: ANN. SURG.

[9] Barber, W. H.: ANN. SURG., Dec., 1914 pp. 723–728; ANN. SURG., Mar., 1915, 273–275; Jour. A. M. A., Oct. 9, 1915, pp. 1243–1246.

[10] Braasch, W. F.: Jour. A. M. A., Sept. 6, 1919, pp. 731–735.

[11] Archibald: Surg., Gyn. and Obstet., May, 1919.

THE CONDITION OF THE APPENDIX IN FIVE HUNDRED LAPAROTOMIES ON PATIENTS REPRESENTING NO SYMPTOMS OF APPENDICITIS

By John T. Williams, M.D.

Assistant Visiting Surgeon, Boston City Hospital

and

Robert Slater, M.D.

late House Surgeon, Boston City Hospital

of Boston, Mass.

(From the Gynæcological Service, Boston City Hospital)

The writers have been impressed with the large number of pathological appendices met with in the course of the routine examination of the right iliac fossa during gynæcological operations. As no cases diagnosed as appendicitis are admitted to the Gynæcological Service at the Boston City Hospital, there is afforded an unusual opportunity for the study of the appendix during life in patients in whom no lesion of the appendix is suspected. Struck by the frequency of unsuspected lesions of the appendix found during operations for other conditions, the writers have looked up the operation notes on five hundred laparotomies performed on the Gynæcological Service to determine how frequently abnormal appendices have been found.

These five hundred operations were consecutive and covered a period of approximately three years, beginning in 1916 and ending in 1919. One hundred and sixty-seven, or almost exactly one-third, of the patients showed changes in the appendix. In 64 instances the condition demanding operation was inflammatory disease of the uterine appendages. In the majority of these it is fair to conclude that the involvement of the appendix was secondary to the pelvic process. This leaves, however, 103 abnormal appendices not associated with any inflammatory process in the pelvis and producing no symptoms or signs which could be brought out by a careful history or a thorough abdominal and vaginal examination. Perhaps two or three of these were cases in which the appendix was found adherent to a fibroid of the uterus or a cyst of the ovary. In the remainder, approximately 100 cases, the appendix condition can not be ascribed in any way to pelvic disease, and therefore a coincidence so far as any gynæcological cause is concerned.

With few exceptions the lesions of the appendix were chronic in nature. We can not give the exact number of each type of lesion found, as the notes in many instances do not differentiate clearly between an adherent appendix due to a chronic inflammatory process and an appendix buried beneath a pericæcal veil, for example. From our own experience these latter are quite common. In general, all the pathological appendices met with were of one of three types. First: those adherent

in one or more places without gross changes in the muscularis or mucosa. These the pathologist called chronic periappendicitis. Second: those with thickening, complete or partial obliteration, affecting all the coats and definitely the seat of chronic inflammation. Third: those buried under pericæcal veils. These the pathologist variously reported as chronic periappendicitis, chronic appendicitis or appendix negative. All these types were sufficiently common.

This study has demonstrated that nearly one-third of the women operated upon had abnormal appendices without definite signs or symptoms of appendix disease. At least one-fifth of the patients had appendix lesions without signs or symptoms and without any pelvic process which could be considered as an etiological factor; in other words, changes in the appendix without known cause and with no apparent harm to the patient. The importance of this fact lies in its relation to two questions.

First: Do such pathological appendices cause reflex symptoms elsewhere without attracting attention to the underlying cause—the chronic appendix?

Second: Or are these lesions of the appendix of no clinical significance whatever, and is the so-called chronic appendix not the cause of the symptoms commonly ascribed to it as has been claimed by Connell (*Journal of the American Medical Association*, 1916, lxvii, 335)?

Childs (*American Journal of Obstetrics*, 1919, lxxx, 31) in 746 gynæcological laparotomies found 244 pathological appendices. He found the appendix abnormal in 66.66 per cent. of inflammations of the right appendages only, 18.42 per cent. of infections limited to the left tube, 38.38 per cent. of the cases of bilateral salpingitis. The writers feel, however, that outside the cases of pelvic inflammatory disease, Childs ascribes too much importance to the possible gynæcological origin of these abnormal appendices. We believe that most of the appendix changes found are independent of the pelvic condition for which we operated.

Waegeli (*Cor. Bl. f. Schw. Aerzte.-Basel*, 1918, xlviii, 1127) in 896 gynæcological laparotomies found appendix disease which he believed secondary to pelvic disease in $16^{4}/_{10}$ per cent. Lesions of the appendix were more frequent in disease of the right appendages, being present in 75 per cent. of the cases of cyst of the right ovary with twisted pedicle, and in $23^{7}/_{10}$ per cent. of those of right salpingitis. Gomez (*Revista de la Asociacion Medica Argentina, Buenos Aires*, 1917, xxvi, 1085) claims that chronic appendicitis is habitually accompanied by sclerocystic degeneration of the ovaries.

Deaver (*Journal of the American Med. Assoc.*, 1918, lxxii, 1583), Mayo (*Surgery, Gynæcol. and Obstetrics*, 1911, xii, 228), Cheney (*Amer. Journal of the Medical Sciences*, 1918, clvi, 494) and others have called attention to the occurrence of reflex symptoms due to chronic appendicitis—often overlooked. While our histories were not taken with gastric disturbances particularly in mind, and many of our patients did complain of

obscure stomach distress, it is evident that had the reflex symptoms been very severe they would have overbalanced the pelvic symptoms to such an extent that the patient would have been admitted to a medical rather than the gynæcological service.

Connell (*Journal of the American Medical Assoc.*, 1916, lxxvii, 335) has questioned the existence of such a clinical entity as chronic appendicitis. He cites a considerable proportion of cases in which removal of a so-called chronic appendix has failed to relieve the symptoms. He believes that these patients are in reality sufferers from visceral ptosis, chronic constipation, and neurasthenia. Such cases he classes as pseudoappendicitis, and thinks that if appendix changes are present they are a part of the larger process and not the cause of the symptoms. Our findings lend a certain amount of support to his contention, for if, as we have shown, chronic appendix changes may be present in a large number of instances without symptoms, why should it be assumed when they exist in conjunction with certain symptoms that these symptoms are necessarily caused by the appendix changes?

Cheney (*Amer. Jour. of the Med. Sciences*, 1918, clvi, 494) believes that "chronic appendicitis is too often suspected as adequate explanation for obscure digestive ailments—more often than is justified by the facts." He does not deny the existence of such a condition as chronic appendicitis, but feels that the diagnosis is too often based upon insufficient foundation.

Pericæcal membranes were first described by Jackson (*Surgery, Gynæcol. and Obstet.*, 1909, ix, 278) in 1908. He had operated upon nine cases in a single year and formulated a symptom complex, which was, however, similar to that of visceral ptosis, Lane kink, and similar conditions. He thought that these symptoms could be relieved by removal of the membrane and had noted the fact that removal of the appendix in such cases did no good. Jackson believed the membrane to be the result of a chronic inflammatory process. C. H. Mayo (*Surgery, Gynæcol. and Obstet.*, 1911, xii, 228), however, believes that Jackson's membrane is embryonic in origin, and is due to late rotation of the bowel, and descent of the cæcum from its hepatic position after formation of the parietal portion of the peritoneum in the infant. The cæcum then burrows its way into position, carrying an extra investment of the peritoneum before it.

The writers do not feel that they can definitely state what the significance of these various lesions unexpectedly found at operation is. There can be no doubt that many of them are utterly innocuous. We are not prepared to go so far as to state that all of them are without significance, but the writers do feel that we are no longer justified in making the diagnosis of chronic appendicitis with the same confidence as in the past.

It is possible that the conditions found may have a considerable bearing upon the course of acute appendicitis. When an appendix which lies beneath a pericæcal veil becomes acutely infected the result is a well

walled off abscess. There can be little doubt that the difficult retocæcal acute appendices are the result of acute inflammation in an appendix previously buried beneath a pericæcal veil. When the appendix which has been free becomes inflamed, walling off is done only by the protective offices to the peritoneum which takes a certain amount of time. Therefore, in acute inflammation of this type of appendix if we operate early enough we get a free acutely inflamed, gangrenous or perforated appendix with little walling off, and a local, or unfortunately sometimes a general, peritonitis.

SUMMARY

1. About one-third of all women operated on for various pelvic conditions show undiagnosed lesions of the appendix.

2. In some cases these lesions are the result of extension of an inflammatory process to the appendix from the pelvic organs, but at least one woman in every five shows an appendix lesion without symptoms and without discoverable cause (so far as the pelvic organs are concerned).

3. These lesions are nearly all chronic in nature and consist of the following types: (*a*) Adhesions without change in the muscular or mucous coats. (*b*) Chronic inflammatory changes in all the layers. (*c*) Pericæcal veils.

4. The frequency of these lesions is of importance in its relation to two questions:

First: Are such undiagnosed lesions of the appendix the undiscovered cause of reflex symptoms elsewhere?

Second: Is there such a clinical entity as chronic appendicitis, or are the symptoms usually ascribed to chronic appendix disease in reality due to some other condition, and such changes as are so frequently found in the appendix of no clinical significance. We are inclined to this latter view, but do not feel justified in drawing a definite conclusion to that effect on the evidence to date. We believe that this subject offers a fruitful field for further investigation and hope that interest may be aroused to prosecute the study of it to a final settlement of the above questions.

LUNG ABSCESS*

By Nathan W. Green, M.D.
of New York, N. Y.
SURGEON TO THE CITY HOSPITAL, ASSOCIATE ATTENDING SURGEON, ST. LUKE'S HOSPITAL

It has been my experience that there has been reluctance in the minds of medical men in making a clear-cut diagnosis of a lung abscess. The appreciation of the conditions in suppuration within the chest cavity has not been clear. The medical man has frequently had to deal with extra-pulmonary and intra-pulmonary conditions existing at the same time, or consecutive, one to the other.

A lung abscess has excited the greatest interest on the part of able medical practitioners, and from their discussion of the case it has been clear that some doubt existed in their minds as to the condition and as to the proper procedure to follow when the diagnosis had been reached.

It has been my fortune to have seen a number of lung abscesses, some of them accompanying a patently tuberculous condition, others purely chronic and simple, and occasionally a fairly acute abscess. The condition of a well-established lung abscess is one which is difficult to mistake. It may be confused with bronchiectasis, but with very few other conditions.

In the subacute stage it may follow a pneumonia with gangrene, or be concomitant with an empyema, the empyema either starting over the abscess or the abscess may develop subsequent to the manifestation of the empyema. Moschowitz, in his recent article on empyema, expresses the idea that many of the empyemas start from the rupture of a small lung abscess lying closely beneath the surface of the pleura. Whether this is the sequence or not, it is established that a lung abscess may accompany an empyema and there be a direct connection between the empyema and a bronchus through the abscess. Fluid may be injected through an empyema sinus and be expectorated by the mouth. Dr. Walton Martin has used a method of clearing up some of these connecting cavities by injecting through the sinus fluid which excited a cough and at the same time could be shown by its differentiation in color in the sputum.

The presence of a subacute abscess may be suspected when, after either a pneumonia or an empyema, the patient's temperature comes to normal and then gradually rises, accompanied by a hacking cough and a fresh appearance of pus in the sputum, not in large quantities, but more as fairly profuse bronchial secretion. This expectoration may be followed at some time by a sudden burst of considerable pus to be evacuated in a short time, with recession of the discharge to the condition before the abscess apparently broke.

* Read before the American Association for Thoracic Surgery, June 9, 1919.

The chronic lung abscess is the more easily recognized because the picture which the patient presents is more constant. The patient may be one who appears to be chronically ill, or may be one who is in fairly good condition except for his local symptoms. The abscess may be one following a pneumonia caused by influenza, or by a pneumococcus infection, or it may accompany the inhalation of a foreign body.

The chief symptom of the chronic lung abscess is the profuse and very foul expectoration. The amount of expectoration varies through the day. Change of posture causes a variation in the amount. The odor is characteristic, and should enable one to make the diagnosis when accompanied by the history of profuse expectoration. The diagnosis is further aided by means of the X-ray, which will enable one with almost certainty to know the condition he is dealing with. If the abscess has been caused by a foreign body, frequently the foreign body may be detected. If the abscess contains no visible foreign body, yet the area of density around a circle of rarefaction is a very characteristic picture. Occasionally the fluid level, which changes upon change of posture, may be demonstrated.

The pathology of the condition may present the following: The lung abscess may be in the right side, or the left side; the more acute may have soft ragged walls, or there may be several abscesses scattered through the lung simulating bronchiectasis. It may be a single abscess with a rigid wall; it may occur in the upper lobe or the middle lobe or the lower lobe of the right lung, or the upper or lower lobe of the left lung. As we have mentioned before, overlying it may be an empyema. The lung over it may be attached to the parietal pleura following the drainage of an empyema; it may be attached to the parietal pleura if no operation has existed and no history of an empyema; or the adhesions between the parietal and visceral pleura may be surprisingly few. Occasionally a lung abscess may be found on both sides. It may contain a foreign body or it may have been caused by mass necrosis following some form of pneumonia. An interlobar empyema may be connected with an abscess cavity.

The history may be as follows: The patient at first has a penumonia, then there are symptoms of local gangrene of the lung with increased expectoration and foul odor. This expectoration later becomes intermittent; that is, there are large portions of the sputum coughed up during certain periods of the day, and the odor becomes particularly characteristic. It is a sweetish, fetid odor, which is almost always present. (I have seen one case of lung abscess that had practically no odor. This was consecutive to a liver abscess, and through it into the trachea bile was discharging. This undoubtedly kept down the putrefaction.) Developing after these pneumonias, in which a lung abscess is a complication, comes an empyema overlying the area of abscess. This may be the only thing diagnosticated, and may be drained without draining the ab-

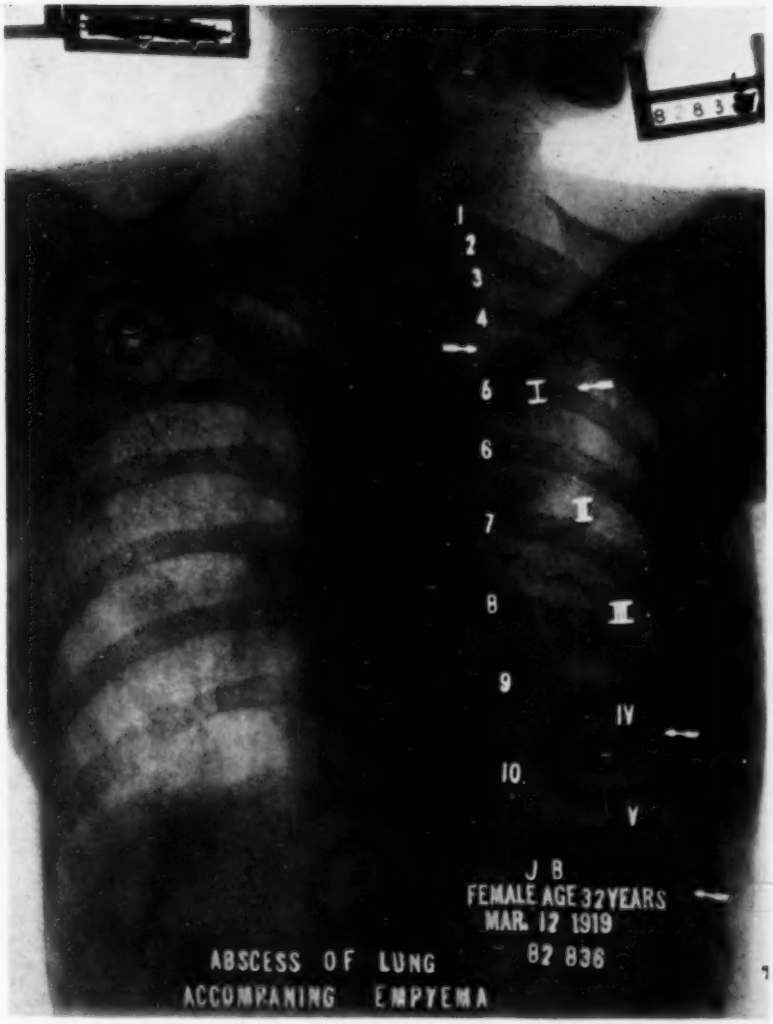


FIG. 1.—Subacute abscess of left lung accompanying empyema. The upper arrows show the location of the abscess. The lower arrows show the location of the empyema.

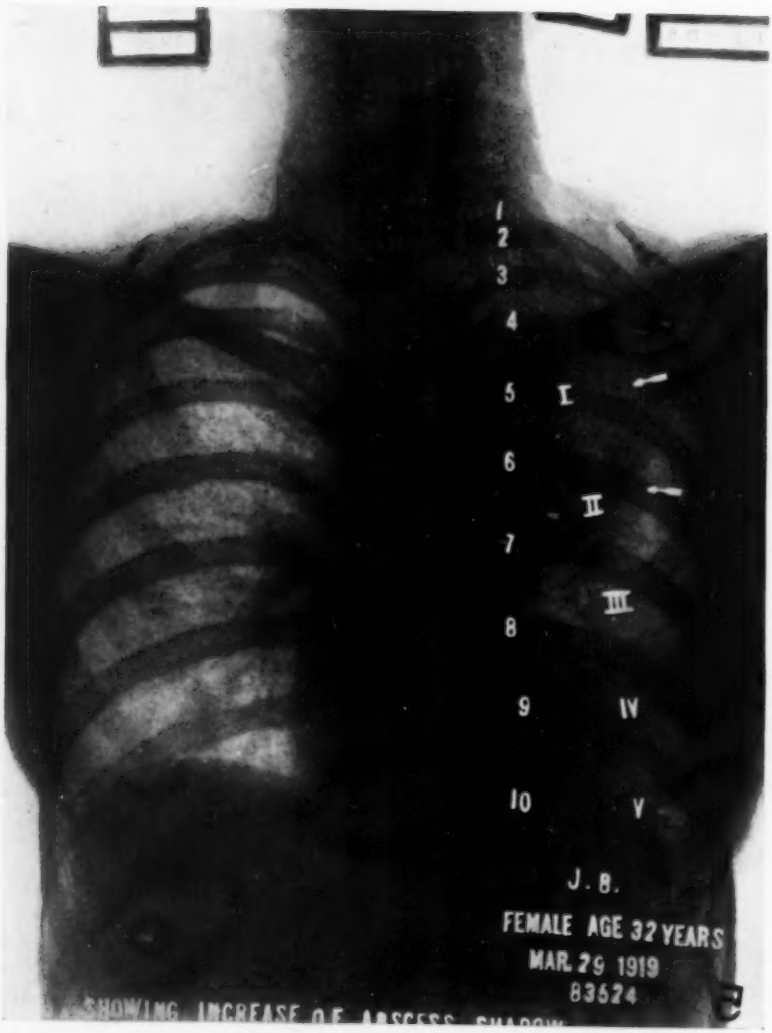


FIG. 2.—Subacute abscess of left lung showing that area of consolidation around abscess has increased, as shown by the shadow.

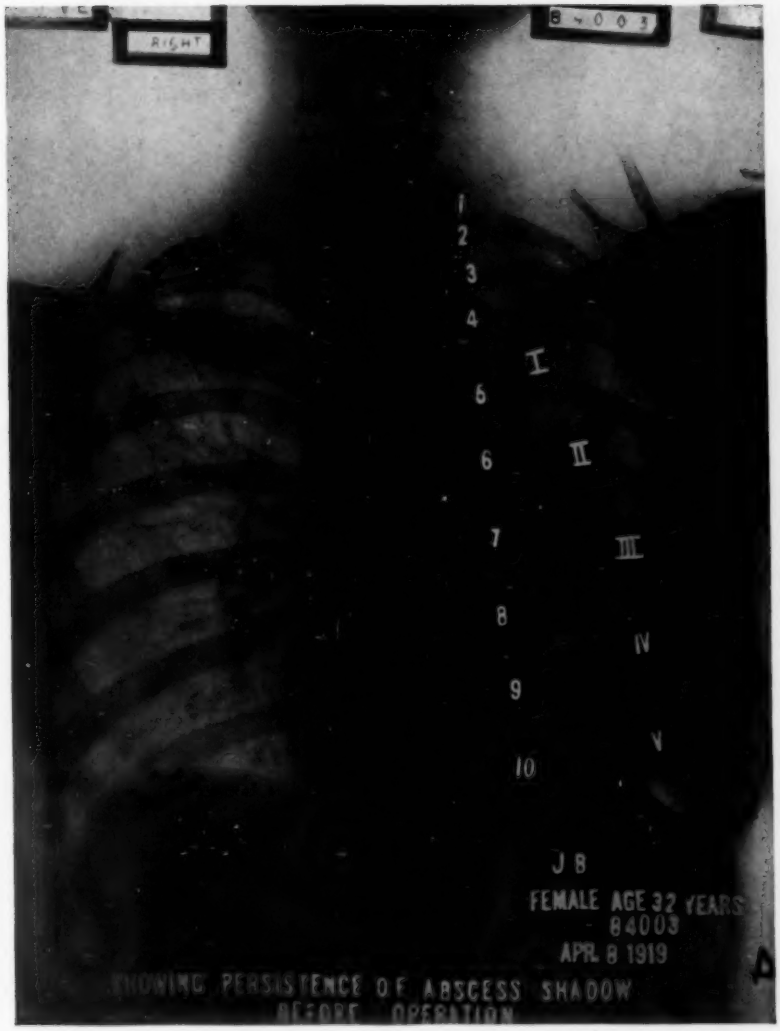


FIG. 3.—Subacute abscess of lung, showing persistence of abscess shadow before operation for lung abscess. The rubber tube is in the empyema cavity.

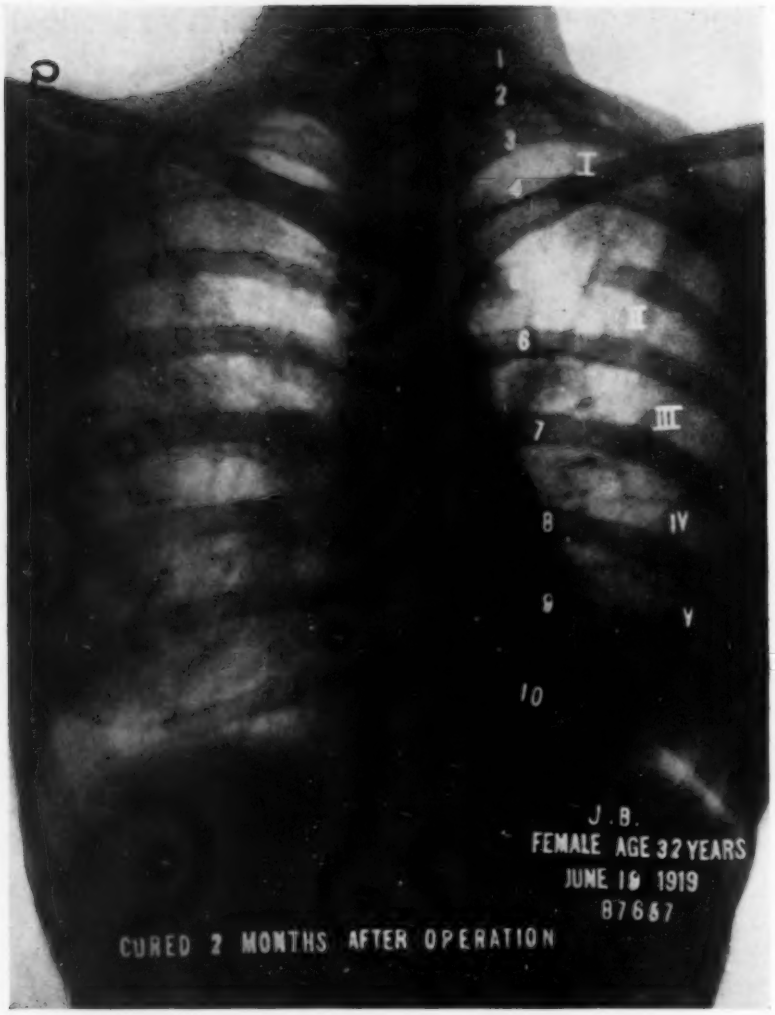


FIG. 4.—Showing röntgenogram taken two months after operation for lung abscess. The sinus is healed and the expectoration has ceased.

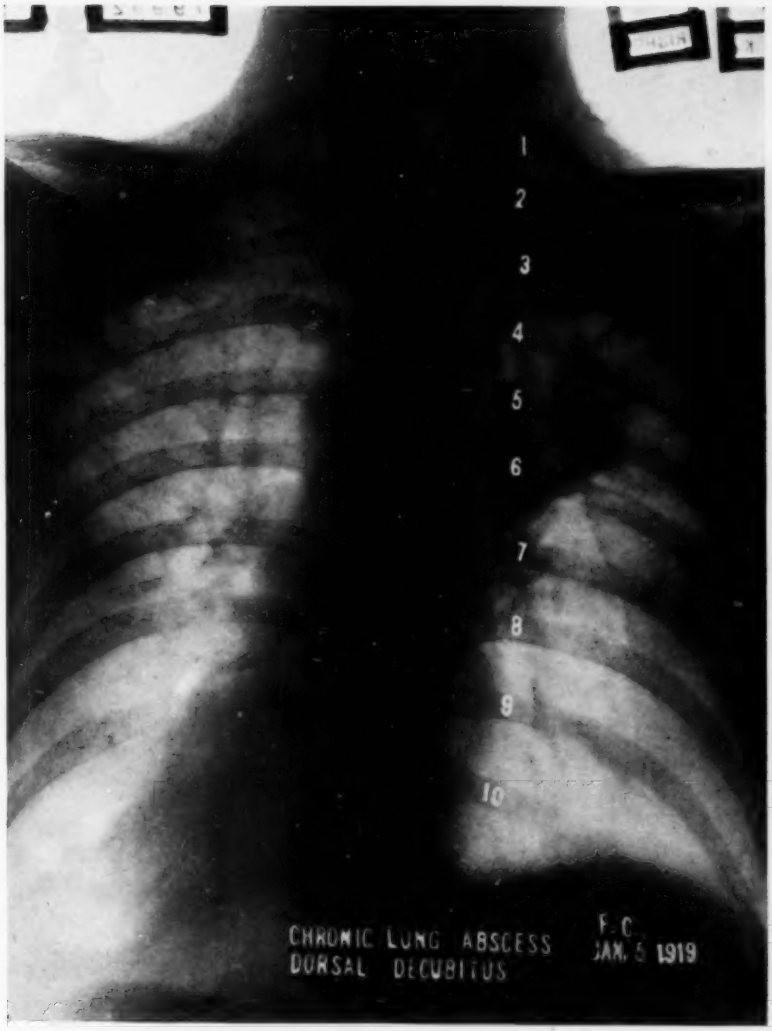


FIG. 5.—Chronic lung abscess in the upper right lobe. This abscess at the time of operation was spherical in shape and one and one-half inches in diameter. It is shown here surrounded by the usual shadow from thickening of the tissue around the abscess.

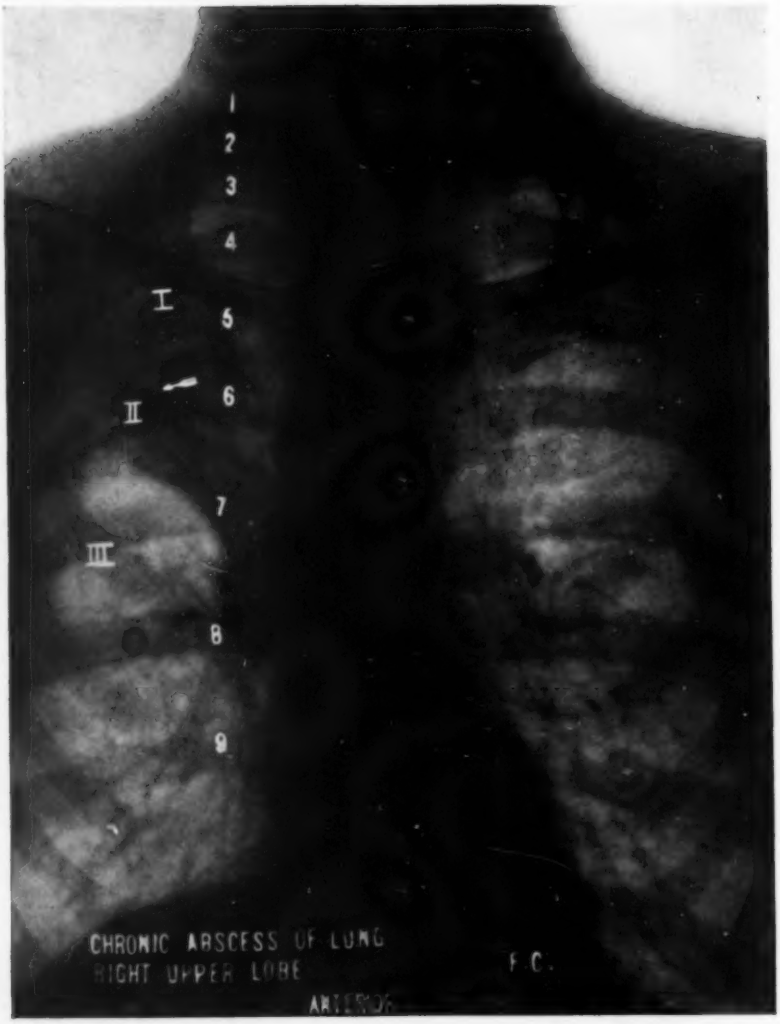


FIG. 6.—The same as Fig. 5, but taken from the opposite direction.

scess; or the abscess and empyema may have a common opening which, when the empyema is drained, drains off through the lung abscess. It has frequently been my experience to open a chronic empyema and see on the visceral thickened pleura a little hole transmitting the air during respiration. (It is probably in such empyemas as this, complicated with a bronchial fistula which undoubtedly had its origin in a lung abscess, that the sudden accidents due to irrigation have occurred. A little of the irrigating fluid has found its way into the trachea and, creating either reflex spasm or an increase in secretions in the larger bronchi and trachea, has formed a diaphragm of froth and bubbles which has suddenly asphyxiated the patient. Professor Schaefer, in his experiments upon drowning in the case of dogs, has demonstrated that a very little fluid in the trachea and bronchi has sufficed to produce death.)

The symptoms of the chronic abscess are as follows: There is always a cough, and the expectoration varies during the day. It is more profuse in the morning. Change of posture aggravates the cough and frequently causes an evacuation of the sputum, which may produce cessation of the expectoration for several hours. There is generally a slight afternoon fever suggestive of mild chronic sepsis. There is a certain amount of anorexia, and the patient does not feel up to par. His weight is below the standard, but there is not a rapidly progressive loss.

The physical signs are sometimes rather obscure and may not of themselves lead to the diagnosis of an abscess. They are generally those of localized consolidation with occasionally cavernous breathing, and if an empyema overlies an abscess, naturally the empyema, being nearer the surface, gives the more predominant signs. The physical signs may vary from time to time, depending upon whether the abscess cavity has been recently evacuated or still remains full of purulent sputum. Clubbing of the fingers is a constant concomitant of chronic lung abscess. It is also present with bronchiectasis, from which it is difficult to distinguish it without further aids to diagnosis.

The X-ray serves to establish the diagnosis and is of very great value. Many of these cases have been thought to be tuberculous and have been sent away to tuberculosis sanitaria. They, however, did not show tubercle bacilli in the sputum. The X-ray picture gives a very different shadow.

A word about the sputum is timely. It is generally of a greenish-yellow color, very profuse, frequently quite free from adhesive mucus, and has a characteristic very disagreeable odor.

The treatment may be divided into medical and surgical. The medical treatment aims to diminish the secretion and deodorize the sputum, and keep the patient in a condition where he may attend to his daily labors and remain reasonably comfortable. This may be attempted by drugs or by a climatological change. The patient's condition may frequently be improved by postural treatment, or he may be made to evacuate his cavity by leaning over the side of the bed and lowering the head

almost to the floor several times a day. If he be an ambulatory case, he can make the attempt to stand upon his hands while his feet are against the wall. (I have seen much benefit derived in one of my cases—a child —from having him "play wheelbarrow." That is, one of his friends would lift up his legs while he ran around upon his hands with his head down. This appealed to his sense of play and, at the same time, evacuated his cavity.)

The surgical treatment is brought into play when the patient finally tires of his condition and is more desirous of relief. Sometimes he complains bitterly of the taste of what he expectorates, and will not consent to palliative treatment longer. The surgical treatment consists in doing a thoracotomy, removing one or more ribs and evacuating and draining the abscess. There is nothing magical in this procedure. The operation may be done in one stage if adhesions exist over the area containing the abscess, or in two stages if adhesions are not adequate, or, if necessary, there may be further stages. It is advisable to make sure of adhesions between the visceral and parietal pleura before attempting to aspirate the pus from the abscess with a needle. This may be constituted the first stage of the operation. One rib may be resected, and underneath it the lung may be found adherent to the parietal pleura and an indurated area detected with the finger. This may be entered by a blunt instrument and enlarged by stretching with a pair of clamps, or it may be opened with a cautery. A drainage tube should then be inserted and a dressing applied. This constitutes a very simple procedure. If the cavity is large it may be necessary to resect more ribs, but these cases should be done carefully and not subjected to too large an operation at the first sitting. The first operation may be used as an index of the patient's power of resistance. If a second operation is done, the procedure must be limited in consideration of this index. No definite prognosis of the time required to heal one of these abscesses can be made. In my experience, each one has been more or less of a law to itself, but I can truthfully say that several have been healed within five months after operation, some of them much earlier.

The operative treatment is simple, and if not too extensive may bring about cures without fatalities. (In the indurated abscesses of the lung it may be that the resection of a lobe of the lung is the only procedure which will effect a cure. This, however, is still only occasionally done.) The operation for the average lung abscess consists in thoracotomy and drainage of the abscess. The details of each operation must be worked out as it progresses.

It is difficult to conceive how artificial pneumothorax can benefit these cases uniformly because in the very spot where one desires the lung to be collapsed adhesions keep it outfastened to the parietal pleura.

My operative experience in this class covers ten cases. One was a subacute abscess following empyema, which followed an influenza

pneumonia. Two of these were abscesses incident to the presence of a foreign body. These were chronic. Another was in a small boy who had evidently also an interlobar empyema. One was in an Italian woman who presented a cavity about as large as the end of a thumb (as she recovered perfectly and there was no autopsy I cannot say whether this was a bronchiectasis or a lung abscess. It was a very smooth cavity without ragged walls). One case was in an Italian man who recovered without further complications. One was in an Italian man and was connected with an abscess of the liver, and was discharging itself through a bronchus. These last two cases were shown before the New York Surgical Society in 1917. (A case I have recently seen has refused operation. In this the level of the fluid could be seen in the fluoroscope.) Another case I had under observation three months with three operations. He finally died, emaciated, and with enlarged cervical glands, and while we were unable to discover tubercle bacilli in his sputum, he had the appearance of having a tuberculous complication. Another case was referred to me from the tuberculosis service of Doctor Miller of Bellevue Hospital. The diagnosis was doubtful, but upon operation a lung abscess was uncovered together with tuberculous lung tissue. This case died shortly after his operation. Another case was referred to me by Dr. Henry E. Hale, with a history of six months duration with foul expectoration coming occasionally during the day. This case had a lung abscess in the upper right lobe an inch and a half in diameter lying under the fourth rib posteriorly. Adhesions were present down to the level of the fifth rib, but none existed below. The free pleura was opened but was again closed without drainage. The abscess was then drained, but a septic pleuritis intervened. This was removed by repeated tapping, and finally by tube drainage. The patient persisted in lying on no other part than his back, which caused the wound to become macerated. He died after a hemorrhage from his cavity on the sixth day after operation. In passing, I will say that were I to again open the free pleura in a similar case, I should put in a potential drain and close the skin over it temporarily, which could be changed into an actual drain by opening the skin. This procedure would have been helpful, but it was not a vital omission.

I have drawn my material from the wards of St. Luke's Hospital, the City Hospital, Bellevue Hospital, and private cases. I am indebted to Dr. Austin Hollis, Dr. E. P. Shelby, Dr. L. F. Frissell, Dr. L. E. La Fetra, Dr. Morris Class, and Dr. J. A. Miller for facilitating me in studying this material. Dr. Lean T. LeWald has given me great assistance with the röntgenograms. I have familiarized myself with the literature, and I must acknowledge the work of Dr. Ian Hall, Dr. Carl Beck, Dr. Emil Beck, Dr. James C. Thompson, Dr. Howard Lilienthal, Dr. Willy Meyer, and Dr. L. Emmett Holt.

Summary.—The diagnosis of a lung abscess, if acute, may be based

upon certain factors, a prominent one of which is a fresh rise of temperature. After recession of the temperature come symptoms of increased cough and sputum, and a changing shadow as shown by consecutive X-rays. The history is that it follows either the inhalation of a foreign body or a pneumonia. The pathology is that of a lung cavity in one side or the other, or possibly on both sides. The physical signs are those of localized consolidation with occasional cavernous breathing and bubbling râles. Clubbing of the fingers is a constant feature. The expectoration is profuse, of a sweetish, fetid odor, rather free from tenacious mucus and of a greenish-yellow color. The treatment is chiefly surgical, and consists in removal of a rib or ribs, with drainage of the abscess through an adherent area of the visceral to the parietal pleura. There are certain lung abscesses with thickened walls which may require more extensive surgical treatment. These will probably not be cured by simply draining. They may necessitate the resection of a lobe of the lung. The procedure for draining the lung abscess may be of a one-, two- or more stage operation. The first stage may be used as an index of the patient's power of resistance. If operative treatment is refused, or seems unjustifiable, postural treatment may sometimes effect a marked amelioration of the symptoms.

TREATMENT OF CHRONIC EMPYEMA

RESULTS OBTAINED AT U. S. GENERAL HOSPITAL NO. 26, FORT DES MOINES, IOWA

By Martin B. Tinker, M.D.
of Ithaca, N. Y.
Lieutenant Colonel, Medical Reserve Corps, U. S. Army
and
John E. Wattenberg, M.D.
of Kansas City, Mo.
Captain Medical Corps, U. S. Army

Empyema in its early stages will not be considered in this paper. Only six cases of empyema have developed at Fort Des Moines, following pneumonia, influenza and pleurisy, an experience of little value compared to the large series of cases reported from the cantonment hospitals of many parts of our country. Suppuration had continued from three to ten or more months in most of our cases at time of arrival at this hospital. The few who were not discharging pus were also anæmic, pale, reduced in weight and strength, with sunken chests, and short of breath. The inadvisability of radical surgery in patients with greatly reduced vitality from exposure, fatigue, prolonged suppuration, and in a number of cases, wound hemorrhage and shock is apparent.

Two main objects were kept in mind: (1) to heal the discharging cavities or sinuses; and (2) to develop the lung and general health and strength to as near the normal as possible. In the general treatment of these cases an effort was made to give the men as good conditions for recovery as possible. Some of the cases were put in beds in the open air, even during winter. The value of fresh air, sunshine, frequent and careful feeding, was kept constantly in mind. The only medical treatment needed was iron tonics, also bitter tonics to improve the appetite. The local treatment consisted in the use of Carrel-Dakin solution in the majority of cases. When a maximum gain had been reached under Carrel-Dakin technic, in case recovery had not already occurred, the sinuses were injected with bismuth paste. In a few cases it was necessary to enlarge the openings, but in only three instances was an operation necessary. In two of these cases the operation was slight and was performed under local anæsthesia.

The following statistical study may prove of some interest:

Since July 1, 1918, eighty cases of empyema have been treated in this hospital. *All but six of these had been operated upon either abroad or in some other hospital in this country.* Six cases were operated upon here. Seventy-two cases (90 per cent.) came here with sinuses discharging from their pleural cavities. Eight cases had healed external wounds, but needed further treatment to redevelop their lung capacity and general physique. Three of these healed cases opened spontaneously within ten days after their arrival here.

The larger percentage of these followed influenza complicated by pneumonia, but a few followed other causes:

Sixty-nine cases followed influenza pneumonia, eight cases followed gunshot wounds of chest, three cases followed acute pleurisy, eight cases had pleurobronchial communications. The sides affected were: Right side, 43 cases; left side, 37 cases; both sides, no cases. All patients admitted had had an operation. The resections were as follows:

Sixty cases with one rib resected. Seventeen cases with two ribs resected. One case with four ribs resected. Two cases with no rib resected.

In the case with the resection of four ribs a part of the lung had been resected following gunshot wound of the chest.

From our observations the argument in favor of removing more than one rib for the purpose of drainage alone does not seem to be strengthened. It required an average of 122 days for permanent closure of the wound, but the average time for healing after arrival at this hospital was only thirty-four days. The method of packing gauze into the wound around the Dakin tubes so as to keep the wound patent, until cured, is, of course, not feasible in a rib resection. What naturally follows is the closure of the skin and soft tissue wound up to the point where it closely hugs the Dakin's instillation tubes. This frequently takes place long before the empyema cavity is healed. Even if two ribs are removed, the advantage of the larger opening is present only at the beginning of the treatment, exactly at the time when the removal of one rib gives sufficient opening. A consideration of perhaps minor importance is the aim to do as little damage as possible to the tissues.

In single resections, the ribs chosen were as follows: Eighth rib, 36 cases. Seventh rib, 20 cases. Ninth rib, 6 cases.

Where two ribs were resected the following were selected: Seventh and eighth ribs, 10 cases. Eighth and ninth ribs, 5 cases. Second, third, fourth, and fifth, 1 case.

The site chosen for operation varied as follows: Posterior axillary line, 40 cases. Mid-infrascapular line, 30 cases. Anterior axillary line, 10 cases.

The site chosen and the rib selected did not seem to have any important bearing on healing. Most of the cases who had been operated upon in English hospitals were operated in the mid-infrascapular line.

The cases had been suppurating for various lengths of time prior to their admission here. The following tabulation includes all the patients that entered here, regardless of character of previous treatment: Longest time of suppuration prior to admission, twelve months; shortest time of suppuration prior to admission, three weeks; average time of suppuration prior to admission, four months.

Of the patients having the largest cavities and the greatest amount of discharge, and on whom Dakin's treatment was used after admission here, the time of suppuration prior to admission here varied as follows: Longest time of suppuration prior to admission, eleven months; shortest time of sup-

puration prior to admission, 21 days, average time of suppuration prior to admission, four months.

Forty patients are considered in this class. In these the time required for healing after admission here varied as follows: Longest time required for healing after admission, three months; shortest time required for healing after admission, twenty-one days; average time required for healing after admission, thirty-four days.

The question as to how soon a patient should be operated upon after making the diagnosis of empyema by thoracentesis has received varied consideration. Of the cases here considered the time from the date of diagnosis of empyema to the day of operation was as follows: Longest time, twenty-two days; shortest time, none; average time, seven and three-tenths days.

We have the right to assume that the diagnosis of empyema was made promptly in each case. Except perhaps in a few cases of acute pleurisy, one would naturally be very watchful for just this complication. Having a prompt diagnosis we may then infer that the day of diagnosis of the condition was really the beginning of the disease. If this conclusion is accepted the average case was operated upon seven and three-tenths days after the appearance of pus in the pleural cavity. Cases which were operated upon almost immediately after pus was found, did not recover in a shorter time than those that were operated upon later. On the other hand, several who were immediately operated upon showed very untoward symptoms for several days after operation. This was not the case in those operated upon later. This suggests that it is perhaps better to wait from a week to ten days before operating the acute cases.

In no case was a cure effected by aspiration alone. In quite a number of cases the chest was aspirated every day or every other day for from two to three weeks prior to operation. The condition did not improve, much less was it cured.

Only three cases were reoperated here. One of these was a case of gunshot wound of the chest, complicated by presence of a foreign body in the lung.

Eight cases had pleurobronchial communications. In four of these the fistula soon closed and routine Dakin's instillation was used. These healed as readily as the average case without this complication. In cases where the communication persisted, Dakin's solution could not be used. These have been among the most discouraging cases for treatment.

The sizes of the cavities averaged in capacity from 10 cubic centimetres to 2800 cubic centimetres, with an average of 150 cubic centimetres.

Dakin's treatment was carried out as follows:

The external surface was cleansed with neutral soap. A smear for bacterial count and culture was made from the pus. The cavity was irrigated once daily with enough Dakin's solution to fill the cavity. This was repeated until the fluid returned clear. Then a liberal amount of Dakin's solution was given as an instillation every two hours for the rest of the day. Several tubes were placed in different directions in the cavity so that when the solu-

tion was used as much of the cavity as possible was sprayed. When the cavity had diminished to two or three ounces in size and showed disinclination toward further closure, bismuth paste (bismuth subnitrate 10, vaseline 90) was used. The capacity of the cavity was estimated while preparing it for bismuth. This was done by flushing the cavity once a day for three successive days with alcohol (95 per cent.) prior to using bismuth. The paste was injected warm and the tube was withdrawn permanently.

The cases had had varied treatment prior to admission. Many had had Dakin's treatment but an almost equal number had had merely external dressings once or twice daily. As above noted Dakin's treatment was used in a larger percentage of cases treated abroad than in the different camps here in the United States, from which these patients came. Dakin's treatment was used in this hospital in most of the cases. The exceptions were cavities which showed very small capacity, with very little and non-purulent discharge, and in which the predominant organism was not of the more virulent type, and those with bronchial fistulas.

The cases were treated here as follows: Dakin's solution followed by bismuth, 40 cases; Dakin's solution only, 19 cases; bismuth only, 4 cases; dry dressings, 17 cases.

Among the complications that may arise following treatment with bismuth is that of bismuth poisoning. In our series of cases three such instances were noted, but in none was the poisoning of any gravity.

The dry dressing cases were those who had very little or no discharge, but whose sinuses had not entirely closed.

A general average of all the cases for the permanent closure of the wounds from time of operation is as follows: Longest time required for healing, twelve months; shortest time required for healing, twenty-three days; average time required for healing, four and two-tenths months.

After admission here: Longest time required for healing after admission here, five months; shortest time required for healing after admission here, four days; average time required for healing after admission here, thirty-four days.

Dakin's treatment has the same advantages in the treatment of empyema as with other suppurative wounds. In many instances healing occurred in reasonably short time after being Dakinized. Six cases admitted here had had dry dressings only, for from five to eight months. Treatment with Dakin's instillation closed them permanently in from two and one-half to three weeks.

The disposition of those who have left the hospital has been as follows: Transferred healed, 49 cases; returned to duty healed, 10 cases; transferred unhealed, 3 cases.

There have been no deaths on the service. At present there are eight unhealed cases in the hospital.

In addition to the care of the wound itself, unless there was some contra-indication, the patients were given daily lung expansion exercises. Figs. 1 and 2 show a group of empyema patients at this work.

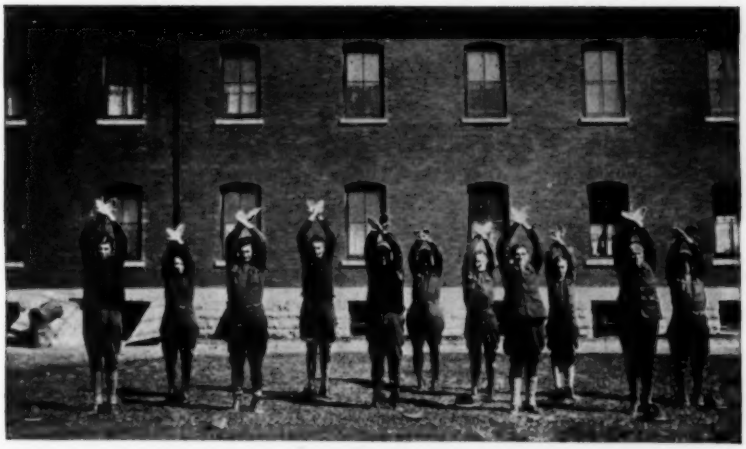


FIG. 1. Group of empyema patients taking breathing exercise. This was not done in any case of rise in temperature above the normal, and especial precautions to avoid over-fatigue were taken with cases in which the hæmolytic streptococcus was present.

FIG. 2.—A group of patients at exercise for chest expansion. The Wolfe bottles were also regularly used three times a day and in addition to this physical exercise of the body given in a systematic course.

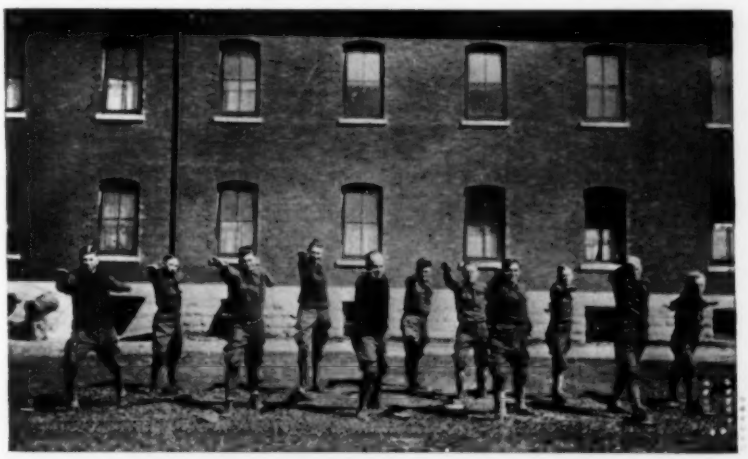


FIG. 3.—A group of empyema patients at arm and shoulder exercises, made more strenuous as the patient's condition warranted it. All had great limitation of shoulder girdle movements on admission.

The form below shows progress of one of the patients. Parts of the record showing no obvious changes have been omitted. This sheet was kept for each patient. The record was made at the time of each exercise and the patient was encouraged to do the exercise on the Wolfe bottles three times a day, making at least three to four transfers each time with bottles of a capacity of one and five-tenths litres. This made about fifteen to twenty minutes of lung exercise three times a day. This was found to be as long as practicable. A longer time overtired the patient. Since the calibre of the connecting tube between the bottles governs the amount of pressure needed to effect the transfer of the fluid of one bottle to the other, the difficulty with which the exercises could be done, could be increased from time to time, if desired, according as the patient's condition improved.

OUTLINE OF RECORD KEPT FOR WOLFE BOTTLES

Name	Date	No. of Transfers of Contents	No. of Expirations Needed for Transfer	Spirometer Reading	Symptoms
	2/2/19	2	18	130 c.c.	Headache
	2/4	3	16		
	2/6	2	15	134 c.c.	Dizzy
	2/8	3	13		
	2/10	3	12	138 c.c.	
	2/13	2	12		
	2/14	2	10	140 c.c.	
	2/16	3	10	145 c.c.	
	2/18	3	9		
	2/20	3	9	148 c.c.	
	2/23	2	8		
	2/24	3	7	150 c.c.	
	2/26	3	7	154 c.c.	
	2/28	3	6		
	3/2/19	3	5	162 c.c.	
	3/5	3	5	168 c.c.	

FIG. 4.

This record serves a twofold purpose in that it indicates the progress to the attending surgeon and serves as a stimulant to the patient if he can see his own improvement. In a disease which runs the better part of a year the factor of encouragement to the patient may become quite significant.

Properly graduated exercises proved universally beneficial. Even the most chronic cases, when observed from time to time under the fluoroscope, showed marked improvement in filling out the thoracic cavity with lung tissue and filling out the lung tissue with air. As the lung capacity increased the endurance of the patient improved also.

A group of empyema patients doing the straddle-hop exercise is shown in Fig. 6. This was used as the endurance exercise of the entire body, but especially of the arms, shoulders and chest. Ninety per cent. of the patients had difficulty in using the arm and shoulder on the affected side. Motions anteriorward and posteriorward, as well as abduction of the arm, were strikingly limited. The average patient was able to abduct only to a point thirty-five degrees outward, comfortably, before exercising. With exercise this condition showed very gratifying improvements.

The gain of lung capacity as shown by the use of the spirometer is illustrated in the accompanying diagram.

The contour of the entire affected side of the chest showed very obvious changes after a month of systematic physical culture. To keep a record of this change a malleable tape was used, made of a strip of lead two feet long, two inches wide and one-eighth of an inch thick. This size was necessary in order that the mould might preserve its shape until a tracing was transferred to cardboard. The tape was moulded about the affected side of the chest. The same level was used each time. One end of the tape was placed at a point which marked the midsternal

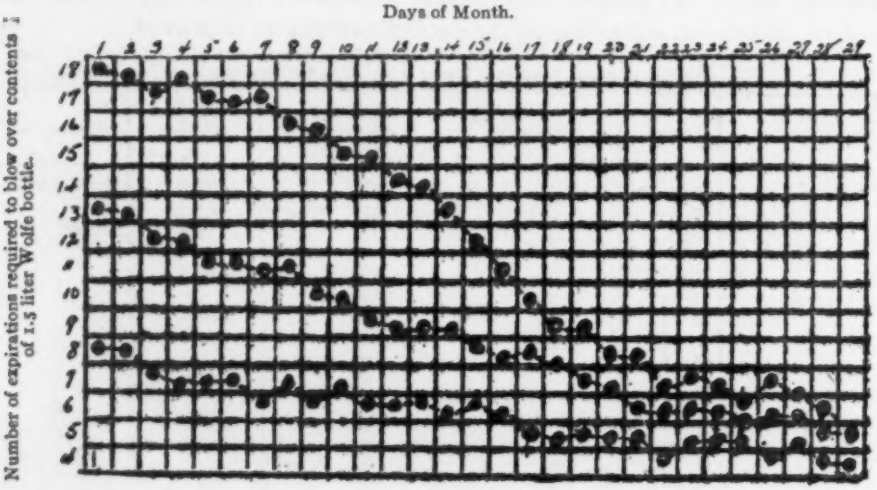


FIG. 5.—Curves showing progress in exercise on Wolfe bottles: Upper curve shows best gain in number of expirations required to blow over contents of 1.5 liter Wolfe bottle; middle curve, the average gain; lower curve, the poorest record.

line at this level. When the chest was at as full inspiration as possible the tape was moulded snugly about the chest.

The figure shows a change in one chest after five weeks' observation while following the daily exercise. This is typical of the results obtained.

All empyema patients took this work. Twenty cases have been followed by careful measurements. Their progress for five weeks was tabulated as follows: Average gain in chest circumference, 3.7 cm.; average gain in chest expansion, 4.3 cm.; average gain anteroposterior diameter, 1.3 cm.; average gain abduction of arm, affected side, 40 degrees; average gain forward motion of arm, 35 degrees; average gain backward motion of arm, 32 degrees; average gain endurance test, 20 minutes; greatest gain in weight, 22 pounds; least gain in weight, 3 pounds; average gain in weight, 17 pounds.

Whether or not healing occurred here, or in a few instances in which the healing occurred before the patient reached this hospital, practically all of the patients had chests which were greatly flattened on the diseased side, the lung capacity reduced, and they were unable to take active exercise because of shortness of breath.

The results of treatment have exceeded our most sanguine expectations.

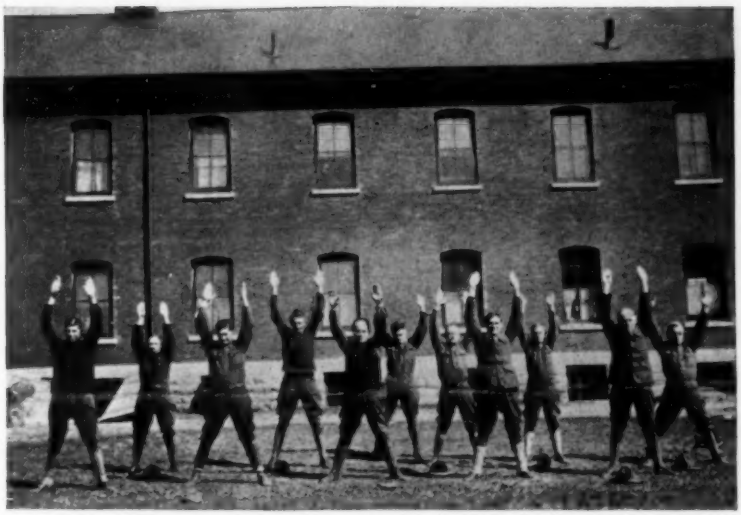


FIG. 6.—A group of empyema patients doing the straddle-hop exercise. Ex-soldiers realize how strenuous this exercise is. Judged by endurance in doing the straddle hop, these men, whose lungs were so badly crippled, are more than equal to the average healthy man.

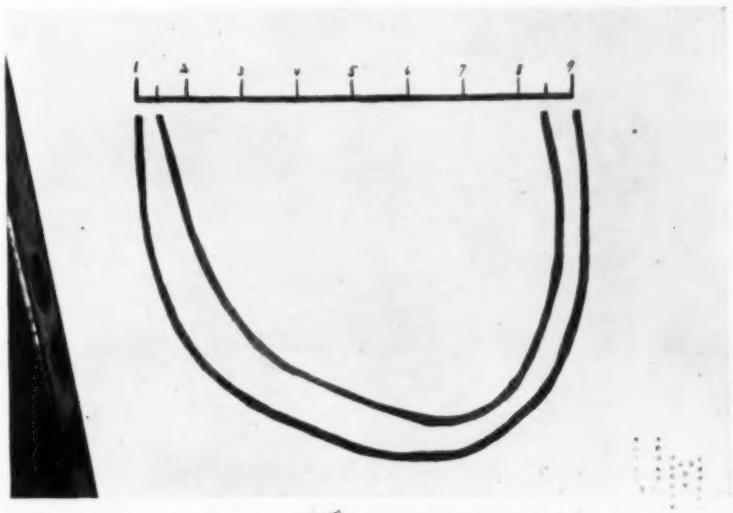


FIG. 8.—Graph of a patient's chest at beginning and end of treatment, taken by moulding lead strip around the affected side, then marking around strip on paper. The gain (in inches) of chest size and contour is average.

For the most part the patients have appreciated the value of the efforts to improve their condition and have been interested and faithful in following out directions.

An average gain in weight of seventeen pounds is certainly encouraging, as is also the great gain in endurance, chest capacity and ability to use the upper extremities. The fact that forty-nine of these patients have been transferred healed; that ten have been sent back to duty; and that only three

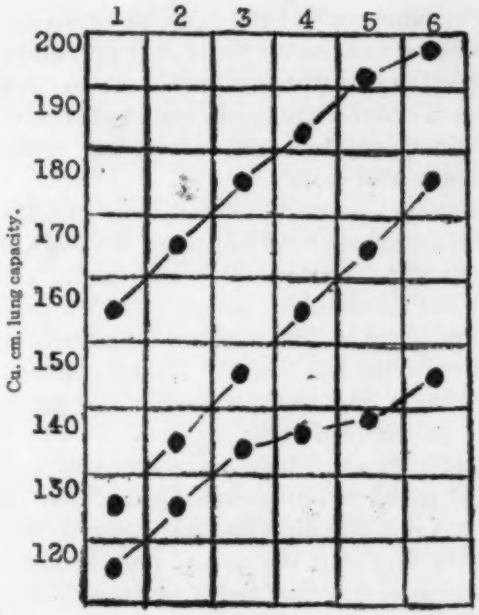


FIG. 7.—Readings on the spirometer indicating gain in lung capacity of empyema patients: Upper curve the best readings; middle curve, the average gain; lower curve, the poorest record.

have required further operative measures, indicates the gain that these men have made.

The prompt healing under two and one-half to three weeks, Carrel-Dakin's treatment at this hospital, of patients who have been suppurating from three to ten months, would seem to indicate unmistakably the value of this treatment where properly used. The healing under bismuth paste has also been gratifying and the three cases of bismuth poisoning have been of little gravity. Some observers have felt that where an empyema cavity has been discharging for several months further operation is usually indicated: our experience gives a contrary impression. The results in this series would seem to justify the conclusion that radical operation is unnecessary in most cases of empyema of not too long standing, and that recovery of health and strength, sufficient to enable a man to follow any usual occupation, is readily possible in the majority of cases.[1]

[1] Shortly following the writing of this paper, April 1, 1919, Ft. Des Moines was made an empyema centre and over 300 cases were treated up to September, 1919, with results essentially as here given. A detailed report of the series is in preparation.

TREATMENT OF CHRONIC EMPYEMA*

By John E. Wattenberg, M.D.
of Kansas City, Mo.
Captain, M.C., U.S.A.

In April, 1919, a summary[1] of the cases of empyema in this (General Hospital No. 26) hospital was made. Since then 121 others have found their way here. Owing to the fact that this group of cases presented problems quite different from the preceding group and thus required somewhat different treatment, it may not be amiss to give the results to others who have been interested in this work.

The cases previously reported had had their primary operations, before simple thoracotomies without adequate drainage, had been extensively used. Nearly every patint who came under observation in the present group had had an operation which gave adequate drainage, usually by the resection of a rib. The rib had often reformed at the site of resection, before the cavity had healed. These cases then were obliged to have further operation, just as the other class of patients who had had too small openings in the beginning.

Most of the patients on admission were still very much undernourished. We had found in our previous cases that the general condition of the patient has much to do with combating his disease. Dunham[2] calls attention to the fact that the actual protein loss to an empyema patient with a draining cavity may be 23 grammes a day. He suggests a "higher calorific diet to conserve the nitrogen of the body." We realized this, and set aside a separate dining-room with special food for the empyema patients. It was remarkable to see the gain in general health, in weight, and with that, improvement in the condition of the empyema. The weights were taken twice each week. Many of the patients gained 40 pounds in three to four weeks' time. Though some did not gain as much as this, all but six gained in weight. Four of these were found tuberculous.

We have treated 201 cases of empyema at this hospital. All but six were of the chronic type and had had one or more operations prior to admission. Twelve had had four or more operations in eight months' time, prior to admission. In the cases having had several operations the most recent were usually in the form of some sort of decortication or collapse of the chest wall. The site that had been chosen for nearly all the operations was the posterior axillary line, and in almost every case the drainage was dependent, at least, when the patient arrived here.

There were admitted 27 cases with pleurobronchial communications, and 2 developed here post-operatively. Of the cases with fistulæ, 6 were gun-

* From the Surgical Service of the U. S. General Hospital No. 26, Fort Des Moines, Iowa. Authority to publish granted by the Surgeon General U. S. A.

shot wounds of the chest, and of the other 23, 16 had had simple thoracotomies without ample drainage prior to admission. Perhaps this is coincidental.

In ten patients who were re-operated here for more ample opening so that Dakin's treatment could be employed, there was found an organized exudate (Fig. 1), which in some instances practically filled the cavity. It was usually whitish or grayish in color, and had a leathery feel and somewhat elastic. It was usually quite adherent to parts of the wall of the cavity, while in other parts it was free. On section it was whitish in color, compact, smooth and glistening. On microscopical examination it showed tissue made up of moderately compact strands of fibrin. There were present numerous capillaries in this tissue. The surface of this tissue was very irregular, thus producing many pockets for pus and bacteria to lodge. It is easy to imagine how futile any antiseptic treatment must be in the presence of such pockets. Dunham has laid stress on the factor of contact in the use of antiseptics. The crypts formed in these cavities by this foreign substance could positively never have been reached and thus not sterilized. That is doubtless the reason why there had been no healing. Hence re-opening was necessary. But if the opening had been adequate in the beginning—and it had not been in any of these cases—probably this condition would never have occurred. Proper care in the first place, namely, adequate opening and proper antiseptic treatment, would have saved these patients further operation, and certainly much time. This organized fibrinous exudate did not re-form in any of the cases operated. These same cases usually had very stiff, thick pleuræ. The lung had great difficulty in re-expanding; the cavity was thus slow to obliterate, and very difficult to sterilize. The patient was slow to recover.

The cases had been treated varying lengths of time prior to admission. The longest time since the primary operation was twelve months; the shortest time was three months, and the average time was seven months.

In reading the enormous quantity of literature which has been written on this subject the preponderance of opinion seems to lie in favor of waiting from one week to ten days, before operating acute cases. This principle had been practically universally followed in the cases here admitted.

Now, with this quantity of material in chronic empyemas, what is the best procedure by which these patients can be made well most quickly, and most safely? As above stated, most of the men entered here had inadequate drainage. Not that drainage is all that a streptococcus cavity requires, but when drainage is insufficient, the chance to apply any sort of antiseptic measures effectively is not merely inadequate, but it is impossible.

The point that was immediately of obvious necessity was to enlarge the opening already present. What means should be employed to accomplish this end? The simplest possible, of course, that would be efficient. This was done. Into the sinuses leading into the cavity were introduced vaselined tubes, which were a size larger than the one being used at that

time. Most sinuses had contracted down to the size no larger than a Carrel tube. In such cases dilatation was begun by introducing a tube just the size larger. From this the size of the tube used was increased gradually. Not all were dilated with equal facility. In some the scar tissue was extremely firm, due, perhaps, to the fact that it was deeper and more extensive, from a more radical procedure in a previous operation. The sizes used are shown in Fig. 2. It was attempted to use a tube a size larger at each twenty-four hour dressing. Often the scar tissue was so difficultly dilated and the patient suffered so much discomfort, that the same tube was obliged to remain in the sinus for forty-eight hours. Rarely was there an instance where a tube the size larger could not be used at the end of that time. While this process of dilating these sinuses is going on, the patient must not expect to be very comfortable, at least not immediately after the introduction of the new tube. As long as it takes the place of an operation, if this is made clear to him, the average patient will be glad to content himself with some degree of discomfort, to forego the more radical procedure of an operation. At worst, it will not be as incapacitating to him for the time being as an operation. The process of dilatation should be continued until there is room for from 4 to 6 Carrel tubes, depending on the capacity of the cavity, and at least one ¼-inch drainage tube. Moschcowitz [3] has called this drainage tube the safety valve. It serves as that and, in addition to that, it assists in keeping the opening sufficiently patent, to allow room for the tubes for instillation of Dakin's solution a few weeks later. When dilating a sinus one must bear in mind that the process of sterilization for which the wound is being prepared, usually lasts weeks, and that the tubes will be crowded very soon, unless sufficient opening is had in the beginning of the treatment. To stop the use of Dakin's solution after a few weeks, in order to dilate the sinus further, is to lose much of the value in antisepsis already gained by the previous sterilization. Bacteria multiply fast when the antiseptic is stopped even for a day. The average length of time required for the sterilization in our cases was twenty-eight days. The tubes used should in all cases be long enough to pass through the chest wall. Greater length is unnecessary and inadvisable, since in small cavities, at least, the tube might interfere with expansion of the lung. Cases can be dilated by this method if there is no interference by bone formation. This can usually be determined at the first examination by introducing an eight-inch Kelly-Pean forceps into the sinus and attempting to spread it. The resistance felt if there is a ring of bone can scarcely be mistaken.

If there is regeneration of bone to such an extent as to make dilation impossible, resection must be resorted to. This was the case in 42 of our last group of cases. The rib above the sinus tract can usually be selected for resection. Fortunately, most of the cases that came under observation here had dependent drainage. It had probably become more so because of the filling of the cavity inferior to the opening by the organ-

FIG. 1.—Organizing fibrinous tissue removed from empyema cavity. Photograph of preserved specimen, about two-thirds original size.

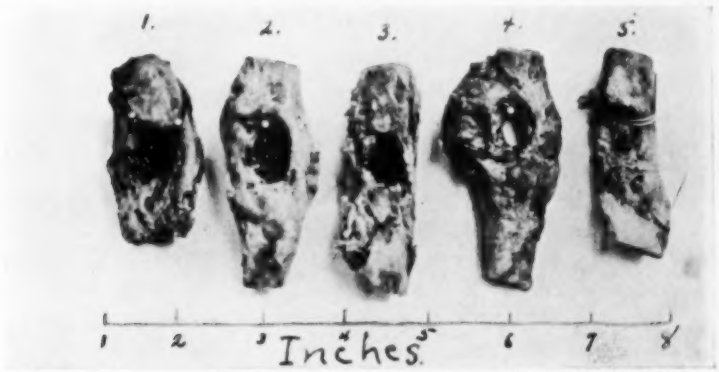


FIG. 2.—Specimens of ribs removed from cases of chronic empyema, showing reformation of bone about drainage tubes, following rib resection.

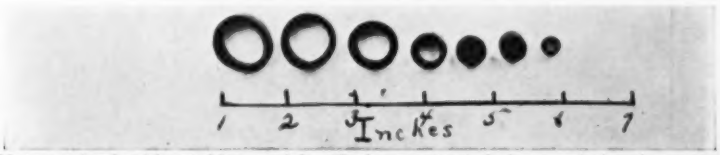


FIG. 3.—Photograph of rubber tubing used in dilating contracted sinuses of chronic empyema cases, showing graduated sizes of tubes.

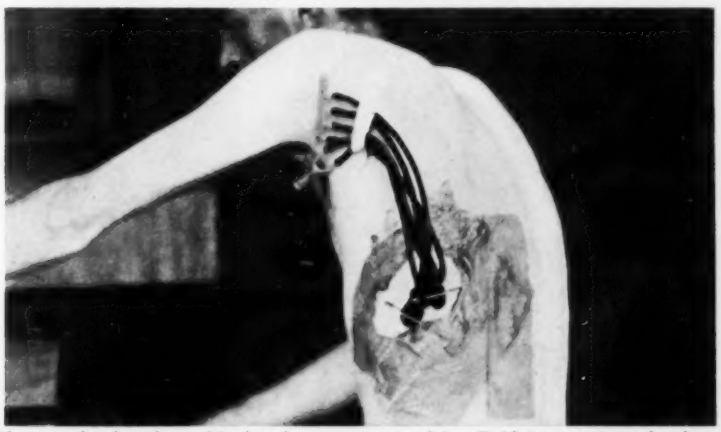


FIG. 4.—Photograph of patient with chronic empyema, receiving Dakin's treatment, showing six Carrel tubes and two large-size tubes for the purpose of dilatation and drainage; vaselined gauze and gauze about tubes shown.

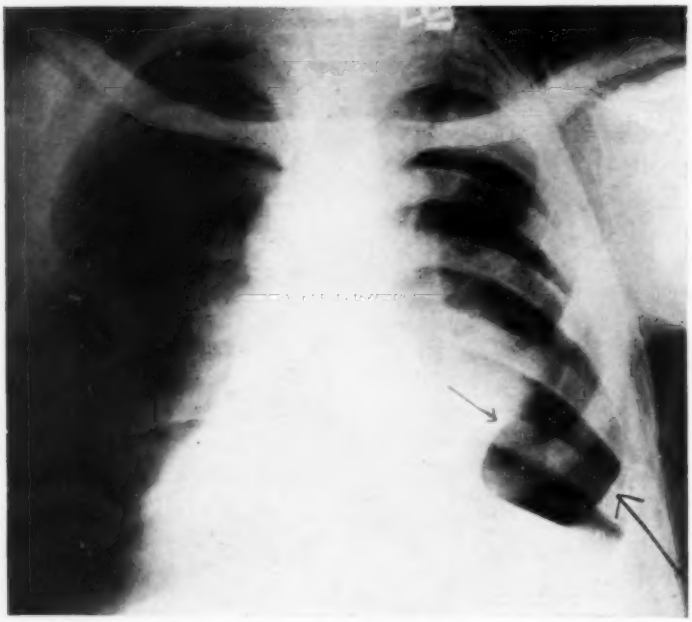


FIG. 5.—Pneumothorax of healed empyema case, after sterilization with Dakin's solution. (Taken May 9, 1919.)

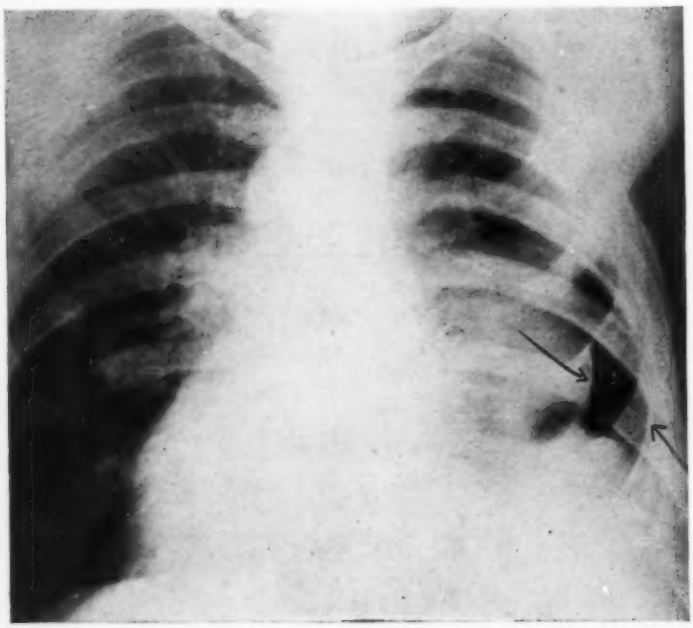


FIG. 6.—Radiograph of same patient shown in FIG. 5, taken June 19, 1919, six weeks later, showing reduction in size of pneumothorax. Permanently healed. Discharged well.

ized fibrinous exudate. In all but 4 of our cases the sinus was at a dependent site. Whether this is the case or not can be ascertained by introducing a curved probe into the sinus before making the incision. If not dependent enough, the rib lower down can be taken.

Very frequently the ribs have not merely reunited end to end, but have been joined to the one above and also below, so that in some instances the operation practically amounts to the removal of solid bone, as in a decompression operation. Specimen No. 1, Fig. 3, was removed eleven months after original resection; No. 2 seven months; No. 3 eight months; No. 4 thirteen months, and No. 5 five months after operation. The holes through the ribs as shown in the specimens are the sites through which drainage tubes passed for the periods respectively indicated. The bone would be solid, of course, had it not been prevented by the presence of the tubes. The sides of the openings through the ribs are very tender when the periosteum has re-formed. It is not very difficult to decide whether the case will require resection or whether it can be treated by a simple dilatation with tubes.

A liberal incision 4 to 5 inches long, parallel with the course of the ribs, should be made. A number of writers have pointed out that this should usually be done in the posterior axillary line as the site of election for the drainage of an empyema cavity. In the chronic cases, re-operated here, the place for incision was always marked by the pre-existing sinus. The importance of using this direction for the skin incision was pointed out by Lieut. Col. Tinker, former Chief of Service here. In following carefully the line of cleavage of the skin, "the incision follows at the same time the chief direction of the subcutaneous connective tissue, blood-vessels and nerves." This is important, so far as hemorrhage from the later application of the chlorine antiseptics is concerned. A large opening is required so as to avoid overcrowding, and thus occlusion of the instillation tubes used. The latter problem becomes quite apparent in even a few weeks' time. On getting down to the pleura, if there is found the usual thick fibrinous exudate covering it, an opening through this must be made by excision of this tissue. Any hope of making an incision into this tissue and then stretching the opening to sufficient size so as to admit the tubes will meet with failure. There is a tendency toward rapid closure of the wound. The opening made may vary somewhat with the size of the cavity, since a smaller cavity, other things being equal, will require the same number of tubes for a shorter time before sterilization. In most cases it is safest to make an opening at least two to three inches in diameter. If there is present any of the organized exudate this is removed.

A point for which I have learned to have considerable respect is that any vessel that seems worth clamping during the operation is also worth tying. We have had three instances of post-operative hemorrhage. None was very serious, but in each case packing with gauze was necessary. If

all vessels had been carefully tied at operation, this would probably not have occurred. I do not think that this is an argument against starting antiseptic treatment early, that is, at least within twenty-four hours after operation. The hemorrhage of one of the cases began a week after operation. The instillation tubes were placed in a position most advantageous to spraying the whole cavity with the antiseptic. Often parts of the cavity could be made to coalesce at operation by breaking down gently with the gloved finger some of the partitions, thus forming one cavity. Six to eight Carrel tubes were used in each cavity, and besides this one or more of the large size drainage tubes were used to fill in the opening and to keep it open. The sizes of the drainage tubes and the number of Carrel tubes used were diminished as the capacity of the cavity decreased. No sutures were used at the end of operation, even though Doctor Chutro partly closes by suture some of his infected wounds in which Dakin's treatment is to be employed. When the tubes have been placed in proper position, gauze is packed into the wound snugly about the tubes (Fig. 4). This was done on the operating table at the time of operation, and Dakin's instillation usually begun the same day. The treatment was given every hour during the daytime, and every two hours at night. During each instillation the patient was required to lie down for five or ten minutes in the hope that this would give an opportunity for better application of the antiseptic. When the cavity had diminished to a sinus, Dichloramine-T (5 per cent.) was used every three hours, and Dakin's solution discontinued. From now on only the drainage tube was left, and it was shortened once a day, the amount of shortening depending on the rapidity of closure of the sinus from within. Our cases closed and were healed on an average of ten days after having reached the sinus stage. So far none has reopened.

Local anæsthesia, though doubtless the choice of anæsthetic in primary cases, is not ideal in these reoperative conditions. The extensive scar tissue infiltrates with difficulty, and where manipulation of the ribs at operation is as extensive as must be the case where the rib above and the rib below have bony connection with the one which the operator is attempting to remove, it is quite unsatisfactory. Nitrous oxide anæsthesia is ideal, and was used in practically all of our cases.

At dressing the skin was cleansed about the wound with benzine, the cavity irrigated with Dakin's solution until the fluid returned perfectly clear. We have heard many suggestions regarding a better method than the changing of all of the tubes daily. The one most frequently offered is to place a tube in the opening, whose lumen would be large enough to permit passing the Carrel tubes through it. This is impracticable for two reasons; it adds new pockets in which bacteria may lodge, and secondly, it hinders flooding of the cavity which, as Dunham points out, helps to remove "any large accumulation of reacting substance" that may exist in the cavity. When irrigating, and also when giving the hourly instilla-

tions, Dakin's solution of sufficient quantity to overfill the cavity must be used. Dunham has pointed out the factor of mass. Fill the cavities to overflowing. This must be done, even if the dressings externally must be changed oftener than once a day.

After having cleansed the skin with benzine it should be dried with sterile cotton handled with forceps. Vaselined gauze is placed about the wound to avoid burning. The tubes are again placed in different directions and the rest of the opening is utilized by the large size drainage tube (Fig. 2). For the safety valve effect alone, tubes of this largest size would not be required, but they are necessary to keep the wound sufficiently patent to allow room later for the instillation tubes. The sizes of the drainage tubes can be made smaller as the condition improves. If kept sufficiently open, dressings are painless, but forcing the instillation tubes into an opening that is too small is painful, and furthermore, it occludes the tubes.

Cultures were taken from the wounds of all the patients twice a week. Immediately after removing all the dressing and all the tubes from the wound, a platinum loop full of pus was procured from the cavity. The same loop was used for the same patient each time. The loopful of pus is placed into a sterile test-tube containing one-half cubic centimetre of one-half of one per cent. of sodium thiosulphate to neutralize the Dakin's solution. The culture then is plated on blood agar. The plates are incubated twenty-four hours. At the end of that time they are examined. If the colonies are numerous, the plate is examined under the microscope. A piece of paper having a hole of four square millimetres is placed into the ocular, and the number of organisms estimated for the standard platinum loop. Five fields are counted and an average is taken. If the colonies are sparsely scattered a field ten square millimetres is used with naked eye, and the total estimated. The percentage of hæmolysis is estimated by comparing the plate examined with a pure blood plate. If hæmolytic streptococci are present the total of these, per plate, is counted. This manner of estimation is, of course, only approximate, but it is practical. Table I is the record of a case which shows the progress of the average patient that has had treatment here, and that has been sterilized.

The hæmolytic streptococcus was present in 100 per cent. of our cases. It was gratifying to witness its early disappearance under Dakin's treatment. Hartwell [4] calls attention to the fact that the hæmolytic streptococcus is not "a deep invader." This factor makes the chlorine preparations ideal antiseptics for this organism. The streptococcus was the first of the organisms to disappear. The treatment has met with favor in dealing with other infected cases here. Orr [5] has employed it with good success in his cases of amputation stumps.

When a negative culture from a cavity was obtained, that cavity was cultured daily until there were seven successive negative cultures. Then all tubes were removed, a thick gauze dressing snugly applied, and the

cavity permitted to close. The dressings were not changed unless they were soiled. The lung filled in the cavity readily and thus far none has given further trouble. Often the cavities closed from within before being completely sterilized. We had 62 such cases. None, however, has ever closed in this manner until the disappearance of the hæmolytic streptococcus.

In our previous group of cases we did not use Dakin's solution in the treatment of bronchial fistulæ. By virtue of the inspiration and advice of Lieutenant Colonel Moschcowitz, our treatment of this condition has changed. We no longer stop Dakin's treatment in a patient with a bronchial fistula. An attempt is made to discover exactly in what posi-

TABLE I.

Date 1919	Per cent. Hæmolysis	No. of Hæmolytic Strep.	Total No. Organisms in Loop
5/22	100	Infinity	1,323,000
5/26	90	"	954,000
5/30	90	"	785,000
6/2	60	1072	620,000
6/6	40	874	430,000
6/11	60	984	323,000
6/14	50	260	255,000
6/18	30	138	153,000
6/22	20	89	421,000
6/25	40	96	245,000
6/29	20	30	122,000
7/3	30	120	98,000
7/6	10	36	139,000
7/9	0	0	210,000
7/12	0	0	139,000
7/16	0	0	85,000
7/19	0	0	8,100
7/22	0	0	558
7/24	0	0	810
7/27	0	0	0
7/28	0	0	0
7/29	0	0	0
7/30	0	0	0
7/31	0	0	0
8/1	0	0	0
8/2	0	0	0

The table shows bacterial count from cavity of typical case of chronic empyema, showing reduction in count with Dakin's treatment.

tion of the patient he can take the greatest amount of solution without causing a cough. Having discovered what this is, he takes this position at each instillation and is given the solution just up to the point where it threatens to induce coughing. Gradually he can take more solution, and in most cases the cavity can soon be filled. The fistula disappears. The average time of closure of the fistulæ of our cases was nineteen days by this treatment. Lilienthal [6] warns against overfilling the cavity in such a patient. This is important. I have heard of deaths thus caused, though I have seen none.

When the cavity has been sterilized and all the tubes are removed, the

opening may close before the cavity itself is entirely obliterated. There will be formed a pneumothorax. This will take care of itself. It soon disappears without further treatment. We have had several such instances (see Figs. 5 and 6).

Great precaution must be taken to keep the Dakin's solution at proper titration. I was told recently by a man who has charge of a large number of patients suffering from infected wounds that he had used Dakin's solution of sufficiently low titration not to cause burns of the skin. He volunteered this statement on being asked why he did not use something to protect the skin against burns. His answer was that he did not find it necessary. I noticed at the same time that 35 out of the 45 cases I saw dressed had macroscopic pus. So far as our experience has been of value to us here, we have seen that Dakin's solution that will sterilize will also burn the skin when the latter is not protected.

The major chest collapsing operations must have had their day. The most radical procedure done to effect a cure here was the resection of from 2 to 2½ inches from one or two ribs.

In the second class of patients who were more recently admitted, were many who had had simple thoracotomies without resection of a rib, in some instances by the trocar method. Diederich [7] has had some wonderful results with the trocar and cannula method, but the cases who came here subsequent to having had this operation we were obliged to reoperate with one exception. There were 21 such cases.

Rodman [8] calls attention to the high percentage of mastoid infections, as a complication in the empyema cases under his observation. We had one case in our series.

Other writers [9] seem agreed that in order to bring out the lung to its former capacity and to fill in the cavity some scheme of increased positive pressure in the lung on the affected side is essential. The simplest method to accomplish this is by the use of blow bottles, watching the gain by spirometer readings taken at stated intervals, perhaps once a week. The help of the positive pressure is especially efficacious after the thick organized exudate had been removed from the cavity wall by Dakin's solution.

In any large group of empyema patients one may expect to find some cavities which will not yield to antiseptic treatment, even though the treatment is carried out very carefully and persistently. Other observers [3] have met with the same problem. Where the cavity showed an inappreciable shrinkage after several months of persistent treatment, and the hæmolytic streptococcus was not present, we removed all the tubes and stopped all treatment, except the external dressings. We have had 8 such cases. Three of them healed permanently two months after removal of the tubes. Two of them were definitely tuberculous, and were transferred to another hospital. Three are still with us. One is a case of severe gunshot wound of the chest with removal of part of the lung at primary operation.

At present there are seven cases in this hospital who are getting Dakin's treatment. There have been three deaths on the service. One was a suicide. His empyema was well and he was to be discharged in two days. One developed a bronchopneumonia thirty-four days after operation and died on the twelfth day of the disease. The other died five weeks after operation. He was tuberculous. There have been twelve transfers to other hospitals before the treatment could be completed here.

No other form of antiseptic was used. The two chlorine preparations, used according to the methods described, seemed to answer all purposes.

BIBLIOGRAPHY

[1] Tinker and Wattenberg: Ann. of Surg., 1919.
[2] Dunham, E. K.: Ann. of Surg., Aug., 1918, lxviii, 148.
[3] Moschcowitz, A. V.: Surg., Gyn. and Obs., April, 1919, xxviii, 337.
[4] Hartwell, Ann. of Surg., July, 1919, lxx, 55.
[5] Orr, T. G.: Ann. of Surg., May, 1919, lxix, 543.
[6] Lilienthal: Ann. of Surg., July, 1919, lxx, 43.
[7] Diederich: Surg., Gyn. and Obs., April, 1919, xxviii, 362.
[8] Rodman: Ann. of Surg., July, 1919, lxx, 49.
[9] Rockey: The Mil. Surg., Oct., 1918, xliii, 384.

THE PATHOGENESIS AND TREATMENT OF LYMPHOSARCOMA AND HODGKIN'S GRANULOMA *

By Isaac Levin, M.D.
of New York, N. Y.

CLINICAL PROFESSOR OF CANCER RESEARCH, NEW YORK UNIVERSITY AND BELLEVUE HOSPITAL MEDICAL COLLEGE; CHIEF OF THE DEPARTMENT OF CANCER RESEARCH OF MONTEFIORE HOSPITAL

(From the Department of Cancer Research of the Montefiore Hospital and Home)

The term lymphosarcoma indicates that the disease is conceived to be a sarcoma, a cancer of the lymphatic tissue. While this conception may be correct in a general way, many pathological and clinical manifestations of the disease present fundamental differences from other types of sarcoma. Moreover, as will be shown later, lymphosarcoma presents only one phase in Hodgkin's disease, and the latter is most probably an inflammatory condition of the lymphatic system.

In order to understand why lymphosarcoma none the less must be classified as a malignant tumor, it is necessary to define the term cancer. This term, as used at present, is in reality a collective name for various pathological processes grouped together as neoplastic diseases—*i.e.*, diseases all the salient features of which are caused by a proliferation of cells.

The cells of an adult animal or plant possess a very limited capacity for proliferation and are endowed instead with differentiated and highly specialized functions. A cancer cell, on the other hand, is a cell which has lost its specialization and regained the power for proliferation which normal cells possess only during the fœtal life of the organism. Furthermore, the cancer cells possess the power of destroying the normal tissues which lie in the path of their development and proliferation.

Cancer is a *local disease* in the sense that the unknown etiological agent attacks a limited group of cells within a certain organ and leaves the rest of the organism, and even the remaining part of the affected organ, uninfluenced. The subsequent growth of the primary, and even the secondary, so-called metastatic tumor, is due to the proliferation and migration of the cancer cells and does not need to be influenced further by the initial etiological agent.

This definition of the pathogenesis of cancer is correct as regards the majority of the types of cancer, but there are notable exceptions within the whole group of neoplastic diseases of the animal and vegetable kingdoms. A brief review of these exceptional cases will aid in the understanding of the distinct position which lymphosarcoma occupies amongst the neoplastic diseases.

* Read before the Section on Surgery of the New York Academy of Medicine, April 4, 1919.

THE POSITION OF LYMPHOSARCOMA AMONG THE VARIOUS TYPES OF NEOPLASTIC DISEASES

The spindle-celled sarcoma of the fowl described by Rous represents a malignant tumor analogous in many respects to human cancer. The tumor infiltrates and destroys the surrounding tissue and metastasis in the internal organs. Like several other carcinomata and sarcomata of the lower animals which have been studied in the last two decades, this tumor is easily transplanted into other normal animals. When a piece of fresh tumor is inoculated by the aid of a trocar needle into the breast muscle of a normal chicken, a sarcoma develops at the point of inoculation. The inoculated animals become emaciated and die within three weeks after inoculation, with all the manifestations of a malignant tumor.

The most remarkable phenomenon in connection with this tumor consists in the fact that it can be propagated not only by inoculation with fresh living sarcoma tissue but also by means of a tumor filtrate passed through Berkefelt's filter. It thus appears that an injection of a filtrate which apparently contains no living cancer cells, but either a chemical agent or an ultra-microscopic organism, is followed by the development of a tumor in the new host. This tumor is usually more benign than the tumors which develop upon inoculation of living sarcoma tissue. It is possible that the metastatic tumors which develop in the chickens inoculated with the sarcoma may also be caused not by migrated sarcoma cells but by the action of the unknown agent which is absorbed into the circulation from the primary tumor. Consequently this condition is in a great many respects analogous to a malignant tumor, while in other characteristics it is similar to an infectious disease.

Another type of cancer which presents analogies to lymphosarcoma is a tumor of plants, the so-called crown gall, described by Dr. Erwin F. Smith, of Washington. The writer has done a considerable amount of research on the subject in collaboration with M. Levine. Crown gall is a new growth caused by the proliferation of a group of cells within the tissue, the normal cells of which do not ordinarily proliferate. The tumor grows invasively and destroys normal tissue. The plants occasionally become stunted and die. The disease is caused by a parasite (Bacterium temefaciens) and may be induced artificially by inoculating the plant with a pure culture of the microorganism. The analysis of the material obtained experimentally by the writer with M. Levine shows that the greater number of these plant tumors behave, morphologically as well as biologically, as benign growths. They grow very slowly; do not interfere with the development of the inoculated plant; compress but do not injure the neighboring normal tissue. Other crown galls appear to be true malignant tumors and dwarf the inoculated plant. Microscopically the cells show a certain amount of invasion and destruction of the neighboring normal tissue.

Microscopical study of the material reveals a great many points of difference from the usual types of animal and human cancers. While a certain number of tumors present a uniform morphological appearance of young

undifferentiated cells, in others the central growing part presents the same appearance while the periphery shows the development of adult differentiated tissue (parenchyma). This parenchyma is a part of the new growth and not a part of the old normal tissue of the inoculated plant. Such an appearance of highly differentiated tissue subsequently to and as a part of the development of a new growth resembles more a process of repair than the formation of a true tumor. Plants do not possess the lymphoid system which plays such an important rôle in the processes of protection and repair of an animal organism. The protection in a plant must always be created by the cell of the tissue which is attacked by the injurious agent. It is quite reasonable to expect that this protection may frequently take the form of a cell proliferation and the consequent formation of a tumor.

The formation of a crown gall may thus be the first step in the protective mechanism of the plant against the invasion of Bacterium tumefaciens. The transformation of a benign crown gall into a malignant tumor is not a frequent occurrence and most probably stands in no direct relationship to the activities of the Bacterium tumefaciens.

The pathogenesis of lymphosarcoma is analogous in many respects to that of malignant crown gall. In an animal organism the processes of inflammation, repair, and tumor growth frequently intertwine, and an inflammatory process may present characteristics both clinical and pathological which render these processes more akin to cancer. In the course of an inflammatory process, the local manifestation—the abscess, inflammatory tumor, granuloma—is frequently accompanied by a general leucocytosis. The number of leucocytes may increase from 8000 to 40,000. This rapid increase in the number of the leucocytes cannot be caused by an overflow into the circulation of the leucocytes from the blood-forming organs, but must be a result of an actual rapid proliferation of the cells within these organs. As a general rule, the leucocytosis, as well as the swelling of the regional lymph-glands, ceases the moment the injurious agent is removed. Should the injurious agent continue to act on the organism, but with less intensity, then the general leucocytosis disappears, but there remains a swelling of the regional lymph-glands.

In syphilis, tuberculosis, and actinomycosis the microörganisms within the gland remain indefinitely active, and therefore the lymph-glands, if untreated, never return to the normal, and the resultant inflammatory lymphoma obtains all the characteristics of a tumor of the lymph-gland—a lymphoma.

THE RELATION BETWEEN HODGKIN'S GRANULOMA AND LYMPHOSARCOMA

Hodgkin's disease represents an actual border-line condition between an inflammatory disease and a malignant tumor. The regional lymphatic glands offer the first barrier to any injurious agent which enters the organism from its surface. Every acute or chronic inflammatory or parasitic disease is usually accompanied by a swelling of the lymph-glands nearest to the port of entry of the injurious agent. These so-called inflammatory lymphomata,

when examined microscopically, show an increase in the number of the lymphoid cells. This accumulation of the lymphoid cells is due mainly to a wandering in from the other lymphoid organs of the body. Very rarely does one see mitosis; instead of it there is a prevalence of the degenerative process in both the lymphoid cells and the reticulum.

The chief characteristic of Hodgkin's disease is also a swelling of the lymph-glands, which increase in size very rapidly. Microscopically, Hodgkin's lymph-glands show an increase in the number of all the types of cells usually met with in a normal lymph-gland—the large and small lymphoid cells and the reticulum cells, as well as frequently the granulated leucocytes, mainly eosinophiles. Morphologically the condition resembles rather an infectious disease than a malignant tumor. The clinical picture of the disease also resembles an inflammatory condition more than a malignant tumor.

Nevertheless, the main features of Hodgkin's disease set it apart from any known parasitic or inflammatory disease. The swelling of the lymph-glands rapidly increases in size and the disease usually terminates fatally, so that in all respects the condition is clinically quite analogous to cancer. Microscopically the main feature of Hodgkin's granuloma is not a degenerative process, as in syphilis or tuberculosis, but an active proliferation of all types of cells of the lymph-gland. This proliferation is limitless and ends only with the death of the organism, and therefore every cell within a Hodgkin's granuloma is biologically identical with a cancer cell.

Some authors still maintain that Hodgkin's disease is a certain type of tuberculosis. It seems to the writer that the most plausible explanation of the pathogenesis of Hodgkin's disease is as follows: The tubercle bacillus, or another infectious agent, is instrumental only in producing the swelling of the first group of lymph-glands. The subsequent development of the disease is analogous to cancer and is due to the fact that the cellular structures of all the lymphoid tissues of the organism become cancerous through the influence of an unknown etiological agent. Furthermore, when the proliferation of the lymphoid tissue in the various organs—spleen, lymphoid glands, etc.—reaches a certain height, then the increase in the size of the individual organs is not sufficient to hold all the lymphoid cells, and the surplus then enters the circulation and increases the number of the lymphocytes in the blood, creating a condition analogous to lymphatic leukæmia. Indeed, it has been shown that a certain number of cases of Hodgkin's disease terminates with an increase of the lymphocytes in the blood, though usually the blood picture in Hodgkin's disease is practically normal.

Lymphosarcoma differs microscopically from Hodgkin's granuloma, insomuch that it usually shows the proliferation of only one type of the cells of the lymph-gland—either the reticulum cells or the lymphocytes. Furthermore, in lymphosarcoma the cells break through the capsule of the gland and invade the adjoining tissue. Kundrat, who first described the disease, considered it to be a separate clinical entity, distinct from Hodgkin's disease. It usually presents itself clinically as a mediastinal tumor involving the

lymph-glands of the mediastinum, or else as a lymphosarcoma of the gastro-intestinal tract.

Notwithstanding these morphological and clinical differences between the individual tumors in lymphosarcoma and a Hodgkin's granuloma, there is no doubt that both conditions may be met with side by side in the same patient, and both are only gradations of the same disease. The writer recalls three consecutive cases which clearly indicate this point. In the first case—an extensive lymphosarcoma of the gastro-intestinal tract—there developed during the clinical course of the disease a simple Hodgkin's granuloma on the right side of the neck, which was encapsulated and circumscribed; and later on there developed a diffuse lymphosarcomatosis in the naso-pharynx. Both conditions promptly disappeared under local applications of radium, while the gastro-intestinal condition continued its progressive course. In two cases, lymphosarcomata were present—in the right inguinal region in the one case and in the right axilla in the other—while in other regions of the same patients there developed simple Hodgkin's granulomata. In still another case the patient, a physician, suffered from Hodgkin's granuloma on the right side of the neck. The case was treated with radium by the writer and the swelling disappeared. Later there developed in the same patient a lymphosarcoma of the mediastinum.

It has been frequently observed by others as well as by the writer that in the same patient one lymph-gland may appear to be microscopically characteristic of Hodgkin's disease while another (lymph-gland) will show a condition of tuberculosis. It is thus evident that there exists a very close relationship between an inflammatory lymphoma, a Hodgkin's granuloma, and lymphosarcoma. It seems most likely that Hodgkin's disease does not begin in a normal lymphoid system. Tubercle bacilli or some other infectious agent produces an inflammatory lymphoma, and subsequently an unknown etiological agent transforms the latter into a malignant lymphoma. When all the types of cells within the gland proliferate, the condition is one of Hodgkin's granuloma. When, possibly as a matter of simple accident, one type of cells dominates over the others, there develops a condition of lymphosarcoma. The latter condition is no more identical with a true sarcoma than the Hodgkin's granuloma itself.

THE DIFFERENCE BETWEEN LYMPHOSARCOMA AND ROUND-CELLED SARCOMA

As has already been stated, the chief characteristic in Hodgkin's disease is unlimited proliferation of the cells of the lymph-glands, and in this respect it is clearly analogous to cancer; but with this the similarity of the two conditions ends. Hodgkin's disease, once developed, is a systemic disease which embraces the whole organism. Not only the visibly enlarged lymph-glands or spleen of a Hodgkin's patient are abnormal, but also the rest of the lymphoid tissue within the organism; even the glands that do not appear to be enlarged or abnormal are undoubtedly affected with the same disease. Lymphosarcoma is only a type of Hodgkin's granuloma and also conse-

quently only one manifestation of a systemic disease. A secondary lymphosarcomatous tumor which develops at a distance from the primary one is not formed through the transportation of cells from the latter, but originates in the lymphoid cells of the region involved.

Round-celled sarcoma of a lymph-gland may be indistinguishable microscopically from a lymphosarcoma, but like any other sarcoma or carcinoma the former develops locally, is not a systemic disease, and produces true metastatic tumors.

THE DIFFERENCE IN THE THERAPY OF CANCER AND LYMPHOSARCOMA

Clinically, a lymphosarcoma may appear to be identical with a true sarcoma in the same region. The chief therapeutic measure in cancer—sarcoma as well as carcinoma—is prompt surgical removal. Recently it has been demonstrated (by the writer among others) that the employment of radium and X-ray therapy before and subsequent to the operation enhances the chances of ultimate success; but operative procedure in the majority of cases is the first therapeutic measure. The opinion seems to be prevalent that the same surgical procedures are to be employed in lymphosarcoma. The pathogenesis of the disease, as related above, clearly demonstrates the fallacy of this procedure. Lymphosarcoma is only a manifestation of a systemic disease which embraces the whole lymphoid system. A discrete tumor of lymphosarcoma is always surrounded by diseased lymphoid tissue, and the operation is followed not by a recurrence but by the development of the latter tissues into new tumors. Moreover, the Hodgkin's granulomata are undoubtedly present at the same time in other regions. The writer has often seen cases in which operation was performed in one region (say the axilla) while there were present at the time of the operation enlarged glands in the other axilla or on the neck. It is self-evident that surgery cannot have any therapeutic value in Hodgkin's disease or lymphosarcoma and may only be employed to obtain tissue for microscopical diagnosis.

On the other hand, the radium and X-rays, which are considered as adjuvants to surgery in sarcoma or carcinoma, are the best known therapeutic agents in Hodgkin's disease and lymphosarcoma.

EXPERIMENTAL EVIDENCE OF THE SPECIFIC ACTION OF X-RAYS ON LYMPHOCYTES

It has been proven experimentally as well as clinically that the leucocytes are the most sensitive cells in the animal organism to the action of radium and X-rays. In a series of investigations in collaboration with M. Levine and B. Joseph, the writer has shown that this influence of the rays on the leucocytes is very finely adjusted. There apparently exists a certain type of rays which specifically affect these cells. Moreover, as these investigations have shown, two cells which may be morphologically identical react differently to these rays. The reason for this discrepancy probably lies in the fact that two morphologically identical cells may differ biologically.

A series of experiments was undertaken by the writer in collaboration

with M. Levine on the influence of X-rays on the lymphocytes of the turtle. This research will be reported elsewhere in detail, and only a few salient points will be cited here. The turtle was selected for the experiments because it has comparatively little of a skeleton and bone-marrow, and as a result the main type of white cells in the blood are the lymphocytes. Very large doses of unfiltered X-rays were employed, and the whole body of the turtle was subjected to the rays.

CHART I

INFLUENCE OF X-RAYS ON LYMPHOCYTES OF TURTLE

Smears	Leucocytes	Lymphocytes
Before X-ray	3	97
Immediately after	60	40
24 hours later	45	55
96 hours later	45	55
120 hours later	42	58
144 hours later	6	94

Chart I shows the differential count of the blood before the X-ray treatment began, immediately after treatment, and 24, 96, 120, and 144 hours later. The chart shows what a great percentage of the lymphocytes was destroyed by the rays, and it also shows that it takes twelve days for the animal to recover from the effects of the rays; then the blood becomes normal again.

After the general effect of the rays on the blood of the turtle was determined, the following series of experiments were undertaken: Two turtles—one on top of the other—were placed under the tube and X-rayed simultaneously. The results are shown in Chart II.

CHART II

INFLUENCE OF RAYS ON LYMPHOCYTES OF TWO TURTLES SUPERIMPOSED

	Leucocytes	Lymphocytes
Turtle No. 1:		
Before X-ray	6	94
After X-ray	81	19
Turtle No. 2:		
Before X-ray	3	97
After X-ray	48	52
Turtle under layer of meat:		
Before X-ray	11	89
After X-ray	84	16

As is seen on Chart II, the percentage of the destroyed lymphocytes is much greater in the upper turtle than in the lower one.

In another series of experiments, a layer of meat or liver, the thickness of a turtle, was placed on the top of the live turtle, and the whole thing X-rayed. In this series of experiments the only turtle used was in the same

relative position to the rays as the second turtle was in the previous series of experiments. It is well known that the general absorption of X-rays takes place in an identical manner, whether the rays pass through a living organism, inorganic matter, or water, so that the only turtle in the second series of experiments received no more of the general radiation than the lower turtle in the first series; but the percentage of destroyed lymphocytes was the same as in the upper turtle of the first series. The explanation for this phenomenon is as follows: The particular type of the rays which was destroying the lymphocytes of the upper turtle became itself destroyed or absorbed in the course of this activity and there was not enough of it left to act on the lower turtle; while in the second series, the meat or the liver did not absorb or destroy any of this type of rays, and the whole amount acted upon the turtle.

The existence of such specific characteristic rays is proven in physics to be correct for inorganic substances. The rays absorbed by gold, for instance, are of a different quality from those rays which are absorbed by platinum, and so on. Thus this research shows that there exists a fine specific adjustment between the rays and the animal tissue on which it acts.

CHART III

Treatment	Poly.	Lymph.	Myelo.	Eosin.
Myelogenous leukæmia:				
No. 1. Before X-ray	42	7	49	2
After X-ray	72	4	23	1
Skeletal metastases of carcinoma:				
No. 1. Before X-ray	71	16	11	2
After X-ray	73	15	12	0
No. 2. Before X-ray	65	7	20	8
After X-ray	67	5	21	7
3 months after	66	23	5	6

Chart III is part of a clinical study which was conducted by the writer in collaboration with Dr. B. Joseph and which will be reported in detail at another date. It is a well-known fact that the rays of radium and the X-rays act very promptly upon the myelocytes within the blood and blood-forming organs of patients suffering from myelogenous leukæmia. The first two lines in this chart show the blood picture of such a case before and after treatment.

Another clinical condition in which the number of myelocytes may be increased in the blood is skeletal metastasis of carcinoma. Case 1 of this series on Chart III shows that the rays produce no effect upon the myelocytes in this condition. In fact, as is seen in the chart, the number of myelocytes even increased after the treatment. In case No. 2 of Chart III again the number of myelocytes increased immediately after treatment; while, on the other hand, three months later, when the clinical condition of the patient improved, the number of myelocytes decreased without the influence of X-rays. The explanation of this phenomenon lies in the fact that the myelocytes in myelogenous leukæmia are analogous to cancer cells. They

proliferate very rapidly and consequently present the type of cells which are readily influenced by radium or X-rays. The myelocytes in skeletal metastasis of carcinoma, while morphologically identical, are biologically a different type of cells; their proliferating capacity is not so great. They are most probably more mature cells, do not proliferate rapidly, and the X-rays exert no influence upon them.

X-RAY AND RADIUM THERAPY OF HODGKIN'S DISEASE

Hodgkin's glands and lymphosarcomata are more promptly influenced by radium and X-rays than any other tumor. The affected lymph-glands diminish rapidly in size, and with it there is a marked improvement in the general condition of the patient. Besides the affected lymph-glands, the spleen should be subjected to the same treatment.

The writer has shown in previous publications that carcinoma or sarcoma under the influence of radium or X-rays may be replaced by dense connective tissue. It is possible that when radium and X-ray treatment of Hodgkin's or lymphosarcoma is begun early and kept up for a sufficient length of time, the spleen and lymph-glands undergo a somewhat similar change in structure. As a consequence, the overproduction of unripe forms of lymphocytes may be permanently inhibited, irrespective of whether the rays produce any effect on the unknown etiological agent of the disease.

The treatment of these conditions should continue for months. Should the treatment be interrupted for a time, then at the first evidence of a new enlargement of the glands the treatment must be repeated. The opinion prevails that the action of the X-rays is only palliative and that ultimately the patients fail to respond to treatment. These unsatisfactory results are probably due to the fact that radium and X-ray treatment is attempted only late in the course of the disease and is not pursued with sufficient energy. In a few early cases the writer succeeded in arresting the disease for a number of years.

Hodgkin's disease presents the most hopeless condition in the whole domain of medicine, and the results of the radium and X-ray treatment are extremely encouraging and should be employed in every case as soon as the diagnosis is made. Moreover, the treatment must be conducted with great energy; half measures are less than useless.

TUBERCULOSIS OF SUBMAXILLARY AND CERVICAL GLANDS IN THE ELDERLY

By Miller B. Hutchins, M.D.
of Atlanta, Ga.

In a rather large experience with surgery of the neck, covering a good many years, and fairly continuous familiarity with current medical literature—though admittedly not complete or perfect—the cases here reported are the only ones of the kind that have come to my knowledge. Search of references would doubtless disclose others, but still leave the condition sufficiently rare to justify recording the three below. The first case was diagnosed clinically, though hesitatingly before operation, the other two were operated upon as unusual types of carcinoma, the diagnosis coming as a startling surprise in the midst of dissection of involved areas, and was grossly self-evident. Doctor Bunce crystallized conclusions from his histological findings in Cases II and III, tissues of Case I not having gone for section, through now tardily regretted negligence on my part.

Cervical tuberculosis, particularly if not exclusively of lymph-nodes, in children and young adults is sufficiently frequent to be commonplace. Theories as to points of entry of infective organisms seem to have been quite thoroughly worked out in the young, but attempts to elaborate explanations in these infections of the elderly—whether old foci elsewhere or foci in the involved structures had lain dormant for years, lighting up in old age, or a recent invasion occurred would simply lead into fields of pure speculation. All old people may have had bad tonsils, certainly nearly all do have bad teeth, if any remain, while reverse infection from bronchial nodes would seem improbable. Case I showed at first strict localization in one area, Case II at first followed the pre- and substernocleidomastoid line, Case III involved the right lobe of the thyroid gland, a node posterior to the inner half and one posterior to the outer section of the clavicle that were palpable, and two or three others, discovered during operation, beneath the central point of the omohyoid muscle. The puzzle under the original diagnosis of carcinoma, in the last two cases, was erratic metastasis as well as rapid development of supposed new growths. Tuberculosis or a family history of this disease was either absent in the two last cases or but faintly suggested, and there were no other tuberculous processes discovered in these patients, but history and gross pathology were intensely marked in first as well as probability that the cheek lesion was the atrium of infection.

Rather detailed reports of cases and treatment seem necessary to understanding.

CASE I.—Mrs. E. S., aged sixty-eight years. Some months prior to examination had a firm-walled granular ulcer in exact middle of left cheek. Healing left an umbilicated scar. Shortly afterwards there appeared about three inches below left facial artery notch in mandible a hard "lump," soon adhering, softening and rupturing, producing a five-cent-piece sized ulcer with base and walls over one-half inch thick. Ulcer was grossly granular and showed efforts at healing.

Lymph-nodes or nodes embedded in posterior part of submaxillary salivary glands constituted a thumb-end sized mass. "Several of her children died of tuberculosis," and when she was told of the probable diagnosis in her case the further information was added that a sister over seventy "was coughing herself to death with consumption."

Operation May 18, 1911. Ulcer treated with nitric acid to seal, and all palpable disease with submaxillary salivary gland dissected out through a circular, undermined skin incision. Facial artery was not injured. A single, deeper, diseased node discovered and removed at end of operation. Dead space and skin wound all closed with plain catgut. Followed, in two or three days, subcutaneous œdema and a red-white reaction of the skin, suggestive of tuberculin response and stitches gave way on fourth day. Incision after removal of submaxillary lymph-node mass exposed globular pus points and miliary foci. Secondary suture was deemed inadvisable because of the low repair capacity of tissue, efforts to aid contraction being exerted by means of coaptive adhesive strips, and cleansing and dressings daily in usual surgical manner; iodoform gauze and dressings, finally systematically roofed over with adhesive strips, air-tight. Curetting of exuberant granulations at times necessary, as well as variations in dressings. Secondary suture was refused by the patient when it would have been successful, and final healing was not accomplished until three months after operation.

May 20, 1912. Area slightly depressed; thin, white, scarcely cicatricial skin covering.

October 27, 1917: Recently (?) developed over carotid, posterior to depression, a little finger-end sized node. Patient, then, six years later, in good health.

CASE II (June 8, 1914).—Mrs. W. A. P., aged seventy-six years (?). Twelve or fourteen years previously I treated successfully a small epithelioma over nasal cartilage.

Present State.—In right temple an indolent semicicatrized epithelioma, quarter-dollar size. Had been cauterized. In spite of most thorough treatment and careful dressings this lesion had not healed on August 24, when for the first time my attention was directed to two finger-end sized nodes, just anterior to middle of right sterno-cleidomastoid muscle, and below these, rather under the muscle, a walnut-sized movable diseased node. Nodes beneath maxillary angle, in lower part of parotid gland and the preauricular node were not palpable. Patient and family insisted that the "growths" were not present forty-eight hours previously. Two days later new lesions were discovered at anterior edge of trapezius. Despite the

unusual distribution and rapid development of the condition, the diagnosis of metastasis from the undoubted temporal epithelioma was made, being confirmed by one of my ablest surgical colleagues.

August 27: Operation for cervical carcinoma, as clean dissection as possible of gland-bearing areas, including lower end of parotid and its now discovered diseased node. A small node ruptured during operation, with its pus and tuberculous structure correcting the diagnosis. Patient died (of embolism ?) one hour and forty minutes after operation—" respiratory failure " was house physician's report.

CASE III.—T. M. O'K., aged sixty-two years. Enlargement of right lobe of thyroid gland first noticed in January, 1919; lymph-nodes infection some time later. Had been in good health save a little cough, which had become aggravated by pressure of diseased thyroid. Thinks he did not have influenza. Tuberculosis, if any, in family—case of an uncle dead fifty years and a brother (?). Throat normal, about half of teeth gone, rest seem good. Hearing intensely bad. Right lobe of thyroid an oval mass directed upward and outward, including tissues over isthmus about two by three inches in size. Posterior to inner end of clavicle a finger-end sized node, another in subclavian triangle. No other could be felt. Beneath skin, the platysma and deep fascia the lesions felt firm, immobile; there was no sense of fluctuation; they were tense, though not hard.

Operation (May 10, 1919).—About five inches incision over and longitudinally to and beyond ends of thyroid. When dissection was about half completed the outer diseased node ruptured, as shortly did the thyroid mass, the two flooding the wound with yellow pus. Nothing remained of the right lobe of thyroid but a bit of anterior part of capsule, pus cavity ascending up between sternocleidomastoid muscle and thyroid cartilage, conically. Remnants of the large nodes as well as two or three small ones in depth of wound showed typical tuberculosis. Hæmostasis was left incomplete with the justified hope that oozing of blood would antagonize reinfection from the pus. Drainage with iodoform gauze from thyroid area and pocket in subclavian triangle was maintained five days in case of the former, by which time it had collapsed and closed. The latter and later abscesses over head of clavicle required four weeks to heal. Closure and healing were markedly speeded up the last week by cotton dressings as compress, covered with adhesive strips to exclude the air—an old and efficient device of my own. The man returned to his home, apparently cured, on June 7, 1919.

The specimens of tissue from Cases II and III were examined by Dr. Allen H. Bunce, of Atlanta. The following are his reports:

CASE II (Lab. No. 11234).—This specimen consists of an irregular mass of fatty and connective tissue containing several enlarged lymph-glands. One gland containing a soft cheesy material has become broken open. Three of the larger glands contain large conglomerate tubercles with extensive caseation reducing the entire glands to a cheesy mass. The smaller glands show a more typical microscopic picture, with many large and small tubercles. Both the macroscopic and microscopic pictures are typical of tuberculosis.

CASE III (Lab. No. 25672).—This specimen consists of an old abscess sac, together with connective tissue, containing 4 or 5 enlarged lymph-glands. Two large adjacent nodes containing cheesy material have already been ruptured. Three smaller nodes dissected from the mass show typical tuberculosis, both upon macroscopic and microscopic examination. No thyroid tissue could be demonstrated in any of the sections.

Summary.—Rarity of tuberculosis of submaxillary and cervical lymph-nodes in the elderly (author's experience), and strikingly unique primary involvement of thyroid gland in one instance. Focus of infection or point of entry unrevealed. Case I, a woman of sixty-eight; possible primary lesion, an ulcer of left cheek, and tuberculous metastasis to lymph-node of submaxillary salivary gland. Six years later another enlarged submaxillary node discovered and not disturbed. This woman was enveloped in tuberculous connections. Case II, woman of seventy-six, refractory, old, typic epithelioma of temple. Sudden and rapid development of apparent "skip" metastasis to cervical glands, diffusion becoming quite complete, even to lower parotid and pretrapezius regions. Diagnosis of carcinoma substituted by tuberculosis on exposure of true condition during operation. Case III, a man of sixty-three, very stupid mentally and exceedingly deaf. Tuberculous history hazy, dubious. Primary involvement of right lobe of thyroid, its complete destruction and replacement by an enormous abscess. Secondary involvement of two nodes in clavicular region, their partial destruction by tuberculosis and pus and early stage of disease in small nodes beneath site of middle tendon of omohyoid. Seepage of blood, purposely provided in Case III, restraining virulent reinfection, though a moderate abscess developed below operative area. Rapid completion of closure and healing of cavities by dressing of cotton in compress form roofed in, air-tight, with adhesive strips, no pus appearing after the first application of this dressing. The use of iodoform gauze strips for drainage, on old theoretical grounds. Clinical recovery of patients I and III, post- (or propter) operative death of patient II, aged seventy-six.

Conclusions.—Tuberculosis of submaxillary and cervical lymph-nodes should be considered in cases of the elderly, and primary development of this disease in the thyroid is definitely established. Carcinoma seems the most likely erroneous diagnosis, but the softer consistence of the masses and erratic, non-serial involvement of nodes should aid in excluding that disease.

Aspiration of cases reported would have revealed pus in at least two of them. The microscope might have completed diagnosis from this aspiration. Less continuous and "clean" dissection and proper after-treatment effective as to cure of disease—whereas a carcinomatous process of equal extent would have almost certainly recurred. Surgical treatment indicated and successful, recurrence of tuberculous condition less probable and more easily controllable than in cases of the disease in childhood and youth.

BENIGN XANTHIC EXTRAPERIOSTEAL TUMOR OF THE EXTREMITIES CONTAINING FOREIGN BODY GIANT CELLS *

By A. C. Broders, M.D.
of Rochester, Minn.
Section on Pathology, Mayo Clinic

The word "xanthic" is defined as "pertaining to or tending toward a yellow color." The yellowish tint is the most striking feature of the benign extraperiosteal tumor of the extremities which contains foreign body giant cells. This tumor has masqueraded under various names, such as spindle-cell sarcoma, myeloid sarcoma, myeloid tumor, myeloma, myeloid endothelioma, myeloxanthoma, granuloma, giant-cell tumor, and giant-cell sarcoma.

Heurtaux, in 1891, differentiated true sarcomas and "giant-cell tumors that are marked by different characters and do not have any tendency to invade the neighboring tissues or organs," which he terms myelomas.

Targett, in 1897, considered the "giant-celled tumors of the integuments" to be, clinically, as well as histologically, malignant growths. The presence of the polynuclear giant cells in the four tumors which he examined suggested to him "that the growths had originated from some bone-forming membrane, such as the periosteum and endosteum; but they were all in the integuments, superficial to the muscles and the tendons, and growing toward the skin rather than in the direction of the bones."

Dor, in 1898, writes that this type of tumor "deserves the name myeloxanthoma." His theory is that "the xanthomatous cells and the giant cells are the result of totally different processes of evolution, but they are derived from identical cells; in the first case the cells remain isolated; in the second case they fuse and their nuclei blend, making a single cell with multiple nuclei."

Bellamy, in 1901, states "that though a myeloid tumor in the sense that it contains an abundance of giant cells among its tissue elements, the growth possesses no true claim to be regarded as a member of this class. . . . The fact that the evolution of the tumor is due to the proliferation of the endothelial cells of the blood-vessels stamps it as an endothelioma; in view, however, of the large part taken by giant cells in its composition, it seems rather to merit the name of 'myeloid endothelioma.'"

Fleissig, in 1913, first distinguished the extraperiosteal growths of the tendon sheaths from neoplastic growths. He states that the tumors called myelomas or giant-cell sarcomas which appear in the tendon sheaths of the fingers, the toes, the hands, the feet, and most probably, the forearm and the leg below the knee are in reality not true tumors. They are not

* Presented before the Southern Minnesota Medical Association, Rochester, June, 1919.

giant-cell sarcomas but inflammatory granulation growths. The simplest designation would be granuloma of the tendon sheaths.

Tourneux, in 1913, collected in his very extensive review of the literature on sarcoma of the tendon sheath 93 cases; about 54 of these should be classed as xanthic tumors with foreign body giant cells. A few of the interesting points of this series are as follows: There were 28 males and 26 females; the average of the ages given for 51 of the 54 patients was 33.1 years; the oldest patient was seventy years, the youngest nine years; the average duration of the tumor in the 36 cases in which duration was noted was four years, the longest duration about twenty-eight years, and the shortest two months. Forty-six of the tumors were located on the upper extremities and 8 on the lower; 32 of the 46 were on the right upper extremity, 13 on the left; the location of one was not indicated. The fingers were affected in 35 cases, the palm of the hand in 7, and the thumb in 4. The index, the second, and the ring finger were each involved ten times, the little finger was involved four times; the location was not indicated in one case. Forty of the tumors were associated with the flexor tendons, 5 with the extensor tendons, and 1 with both flexor and extensor tendons. Four of the 8 tumors of the lower extremities were on the toes, 2 on the third, and 1 each on the first and second, involving equally the flexor and extensor tendons. Three were in the malleolar region and 1 was associated with the extensor tendons of the third and fourth metatarsal bones. Tourneux believes that the color of these extraperiosteal tumors is due to their excessive vascularity.

Stewart and Flint, in 1915, reviewed the literature; they found 9 cases published before 1913 which had not been included in Tourneux's list, and 8 new cases, bringing the total up to 73, geographically distributed as follows: Germany, 26; France, 24; Italy, 12; Great Britain, 7; and Switzerland, 4. To their total should now be added the case reported by Pybus in 1917, and one by Ely in 1918.

Each of Stewart's and Flint's two patients was twenty-seven years of age, one a male and one a female. The tumor in the first case was located on the ulnar aspect of the right thumb; it had appeared two or three years after injury to the thumb by a saw and had persisted for seven or eight years. At operation the tumor was found to be attached by a pedicle to the tendon sheath of the flexor longus pollicis. In the second case the tumor was located on the flexor aspect of the joint of the left wrist. Two and one-half years before examination the patient fell and injured the wrist, which swelled and became discolored. A short time afterwards a small tumor made its appearance and gradually increased in size. It was removed in October, 1911. In January, 1915, the patient had a sound and useful hand with no recurrence.

It is obvious that the various authors quoted do not agree with regard to the true nature of this tumor.

Seventeen cases of benign xanthic extraperiosteal tumors of the ex-

tremities containing foreign body giant cells have been examined in the Mayo Clinic. Brief histories of the tumors are tabulated as follows:

Age and Sex of Patients		
Total number of patients	17	
Females	11	
Males	6	
Average age	47.2	years
Oldest	65	years
Youngest	21	years
Location		
Upper extremities	10	
Right index finger	3	
Right ring finger	2	
Right little finger	1	
Right second finger	1	
Right thumb	1	
Left index finger	1	
Left wrist	1	
Lower extremities	7	
Right ankle	3	
Right foot	1	
Right second toe	1	
Right leg	1	
Left little toe	1	
Lesions		
History of injury	6	
History of infection	2	
Average duration of lesion	7.6	years
Longest duration of lesion	24	years
Shortest duration of lesion	8	months
Average largest diameter	2.8	cm.
Largest diameter	8.7	cm.
Smallest diameter	0.5	cm.
Treatment		
Local excision of tumor	12	
Local excision and cautery	2	
Amputation of toe	2	
Amputation of finger	1	
Ultimate Results		
Number of patients traced	15	
Number living	14	
Number dead	1	
Recurrence	0	
Average period of time since operation	3.5	years
Longest period of time since operation	8.4	years
Shortest period of time since operation	.24	year

The patient reported dead, according to a relative, died from general decline at the age of seventy-three. There had been no recurrence of the tumor more than seven years after local excision.

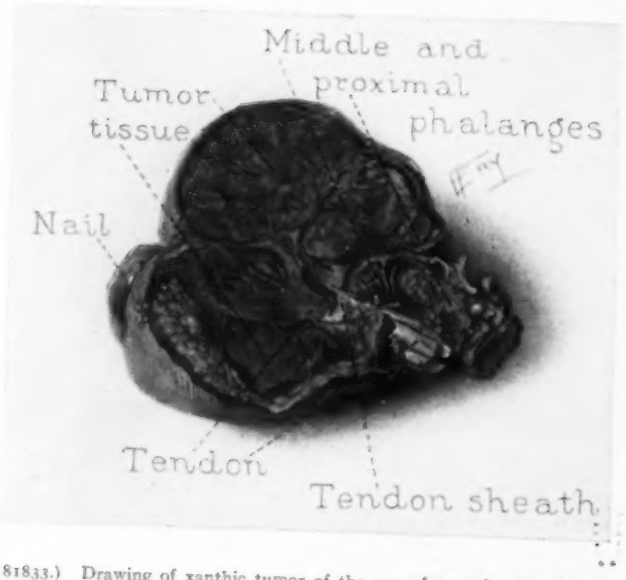


FIG. 1.—(Case 181833.) Drawing of xanthic tumor of the second toe, showing the characteristic color and the close relationship of the tumor to the tendon and tendon sheath.

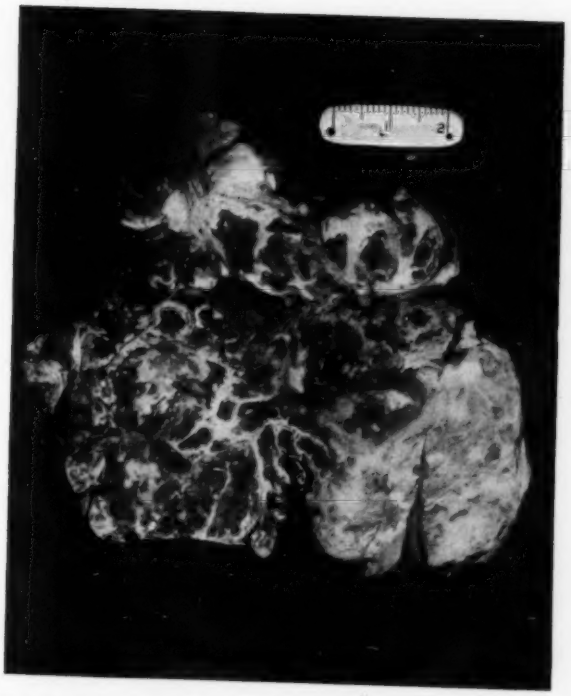


FIG. 2.—(Case 62650.) Photograph of xanthic tumor on the anterior surface of the ankle.

FIG. 3.—(Case 107243.) Photograph of xanthic tumor of the right ring finger, showing close relation of the tumor to the tendon and the tendon sheath. (*A*) tendon, (*B*) tumor, (*C*) tendon sheath.

FIG. 4.—(Case 269555.) Photograph of xanthic tumor of the anterior surface of the leg, between the skin and the superficial fascia.

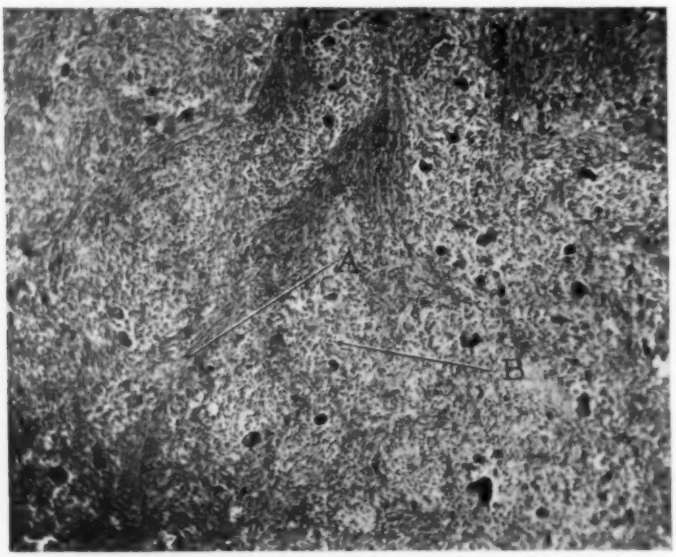


FIG. 5.—(Case 181833.) Photomicrograph of xanthic tumor of the second toe, showing fibrous and cellular areas with numerous foreign body giant cells. (*A*) fibrous area, (*B*) cellular area. Same case as FIG. 1. x50.

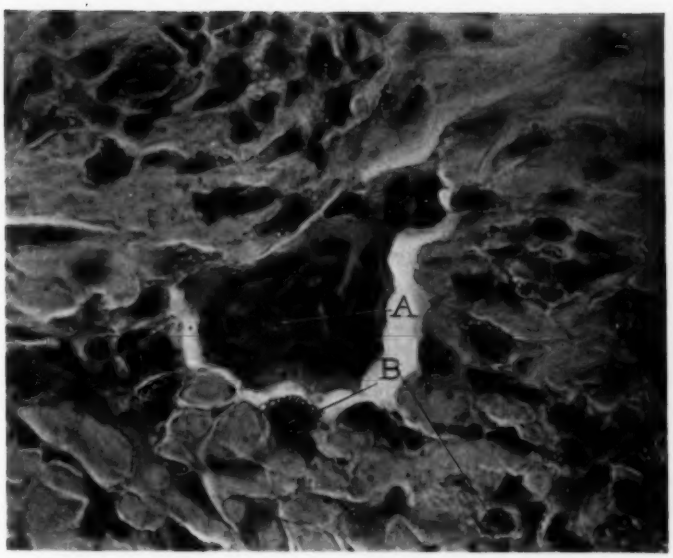


FIG. 6.—(Case 69382.) Photomicrograph of xanthic tumor showing a typical foreign body giant cell surrounded by fibroblasts, fibrous tissue, and phagocytes. (*A*) giant cell, (*B*) phagocytes. x500.

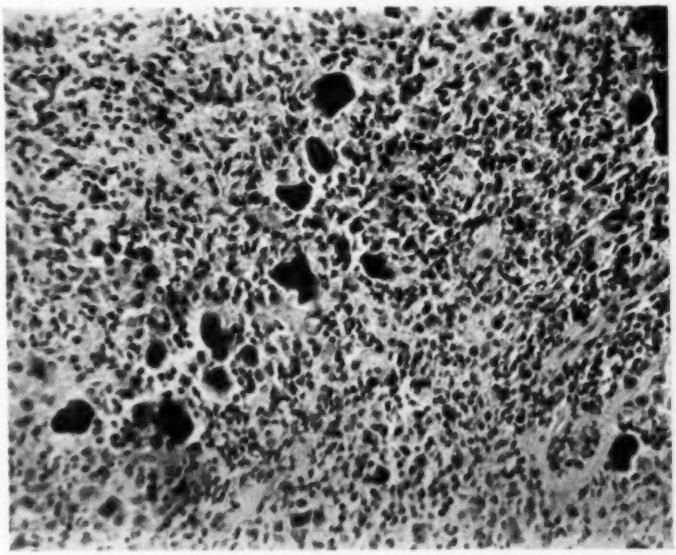


FIG. 7.—(Case 225403.) Photomicrograph of xanthic tumor with a number of foreign body giant cells. x100.

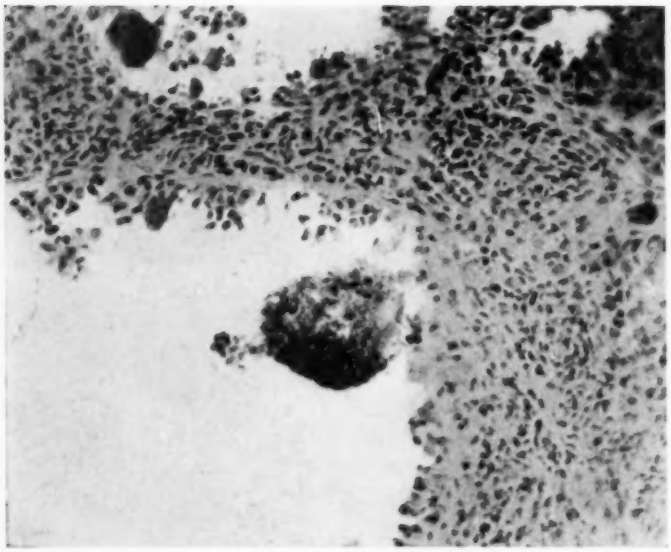


FIG. 8.—(Case 69382.) Photomicrograph of xanthic tumor; foreign body giant cell absorbing blood pigment in an alveolar space. x120.

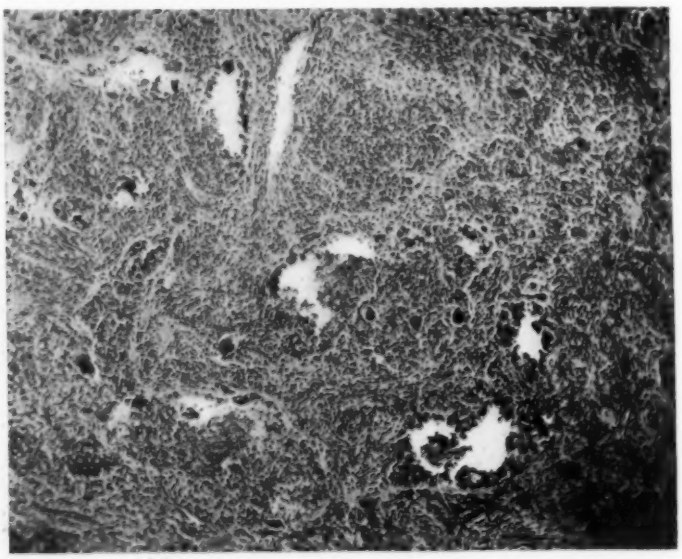


FIG. 9.—(Case 69382.) Photomicrograph of xanthic tumor showing alveolar spaces and foreign body giant cells. x50.

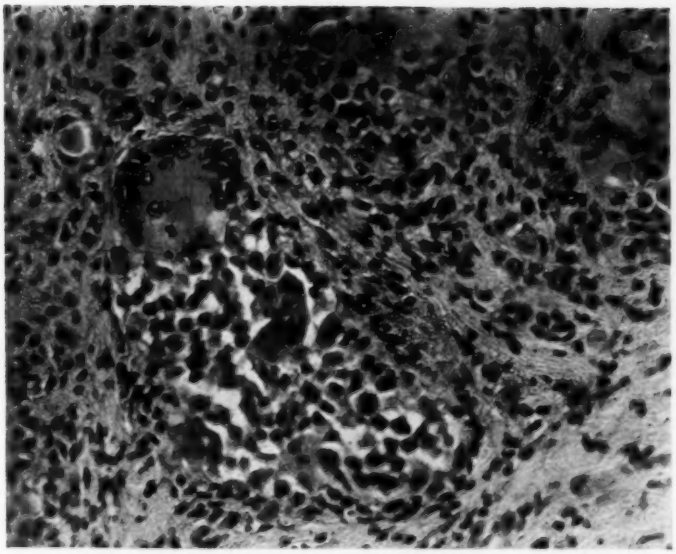


FIG. 10.—(Case 174019.) Photomicrograph of xanthic tumor; endothelial cell proliferation and foreign body giant cells in alveolar space. x180.

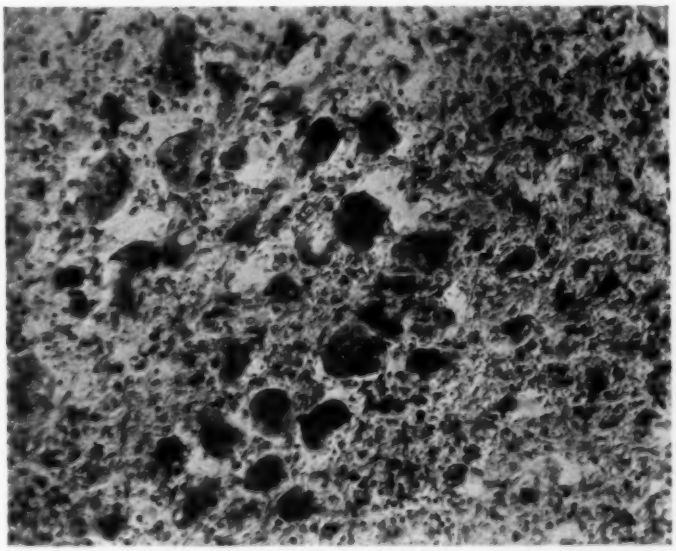


FIG. 11.—(Case 202110.) Photomicrograph of medullary giant cell tumor of the tibia showing numerous foreign body giant cells. x100.

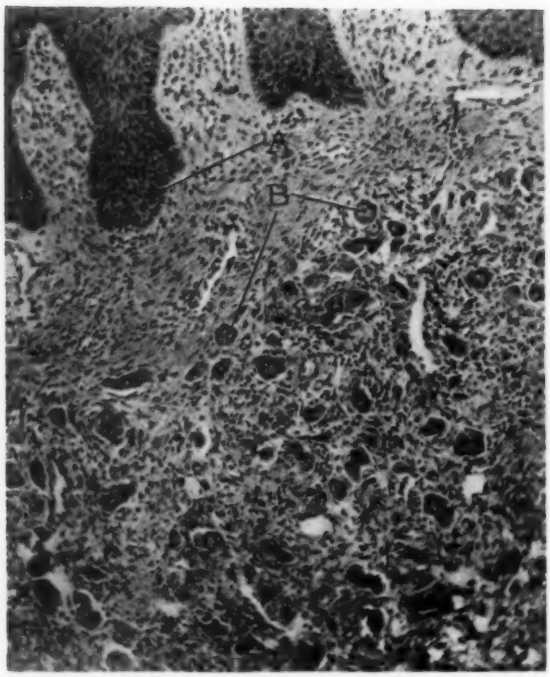


FIG. 12.—(Case 186283.) Photomicrograph of giant cell tumor of the gum (epulis). (*A*) epithelium, (*B*) foreign body giant cells. x70.

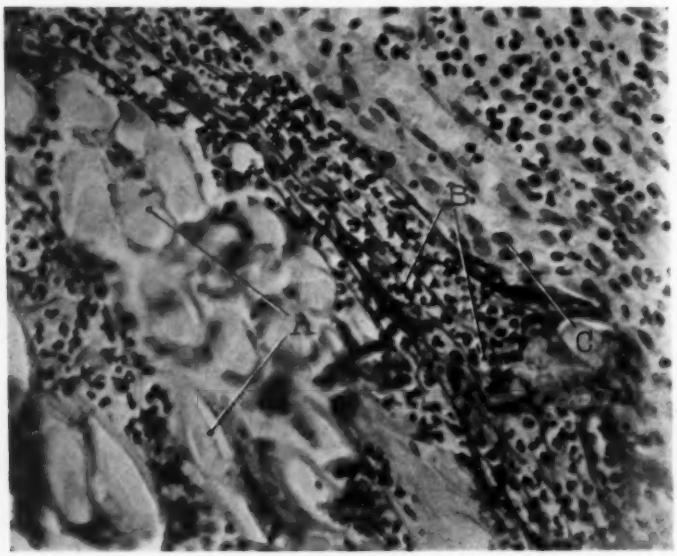


FIG. 13.—(Case 260329.) Photomicrograph of nonabsorbable suture material in gastrojejunal ulcer. (*A*) nonabsorbable suture material, (*B*) polymorphonuclear leucocytes, (*C*) endothelial leucocytes. x200.

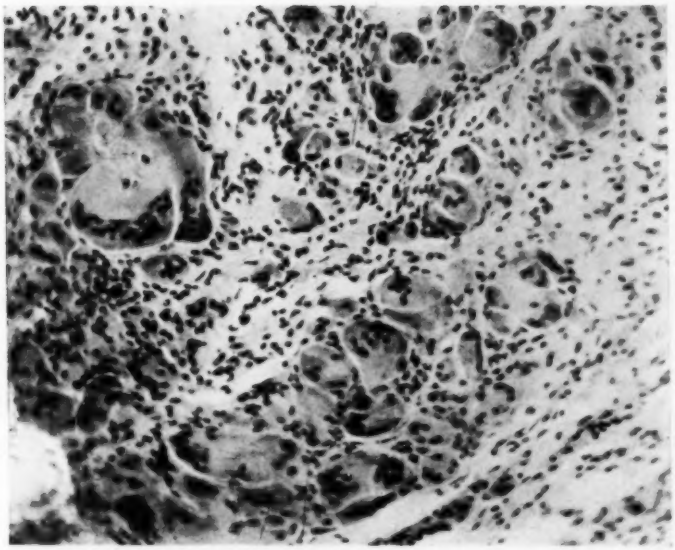


FIG. 14.—(Case 260329.) Photomicrograph of foreign body giant cells near nonabsorbable suture material in a gastrojejunal ulcer, same as Fig. 13, different field. x100.

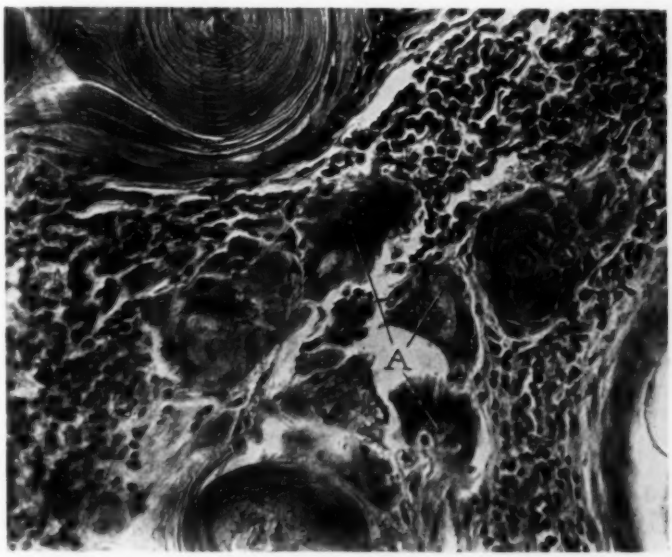


FIG. 15.—(Case 56099.) Photomicrograph of foreign body giant cells absorbing cornified epithelium in an epithelioma of a lymph gland. x200.

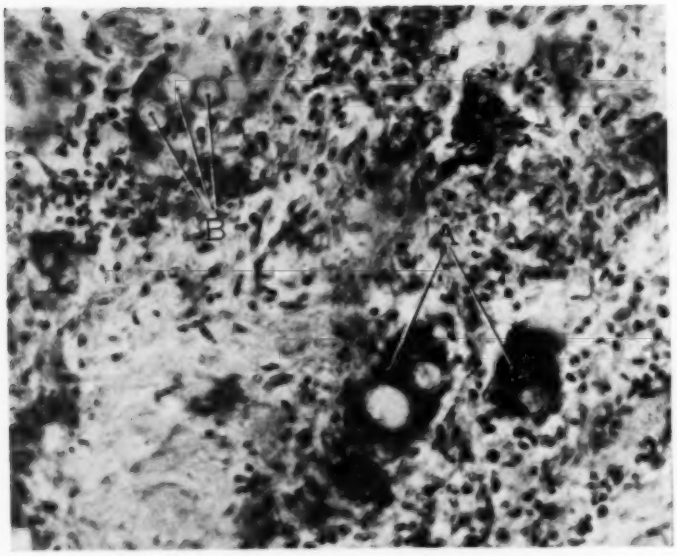


FIG. 16.—Photomicrograph showing foreign body giant cells in a case of coccidioides immitis. (*A*) giant cells containing coccidioides, (*B*) coccidioides. x200.

FIG. 17.—(Case 59139.) Photomicrograph of tuberculosis associated with epithelioma, showing foreign body cells. (*A*) tuberculosis, (*B*) epithelioma, (*C*) giant cells. x50.

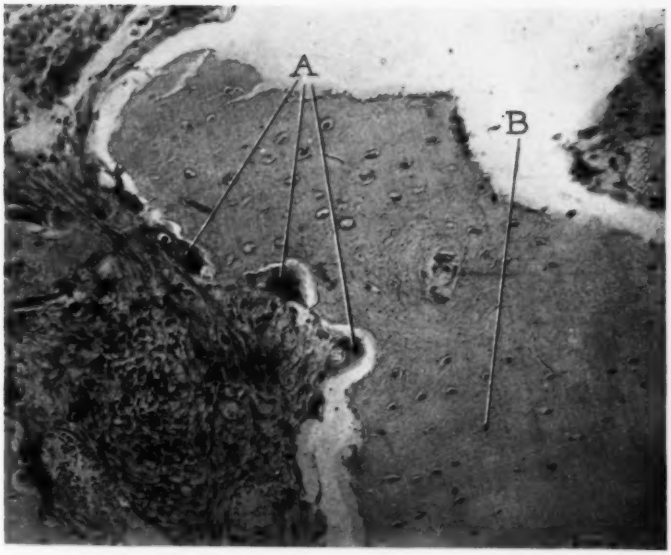


FIG. 18.—(Case 219836.) Photomicrograph of (*A*) osteoclasts or giant cells absorbing the bone, (*B*) bone. x100.

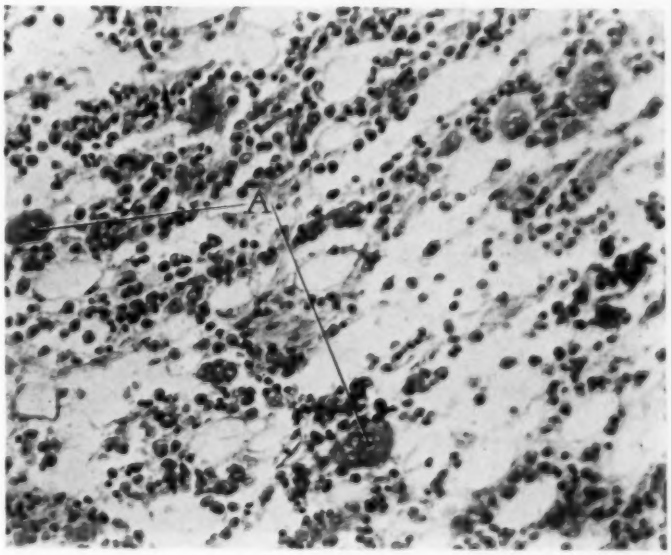


FIG. 19.—Photomicrograph of bone marrow, (*A*) osteoclasts or giant cells. x50.

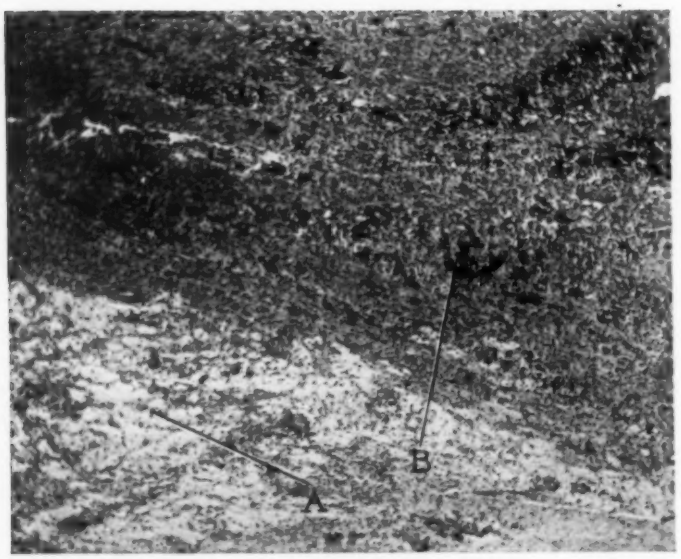


FIG. 20.—(Case 74057.) Photomicrograph of xanthic tumor showing (*A*) xanthoma or foamy cells, (*B*) blood pigment. x50.

FIG. 21.—(Case 62650.) Photomicrograph of xanthic tumor showing xanthoma or foamy cells. x100.

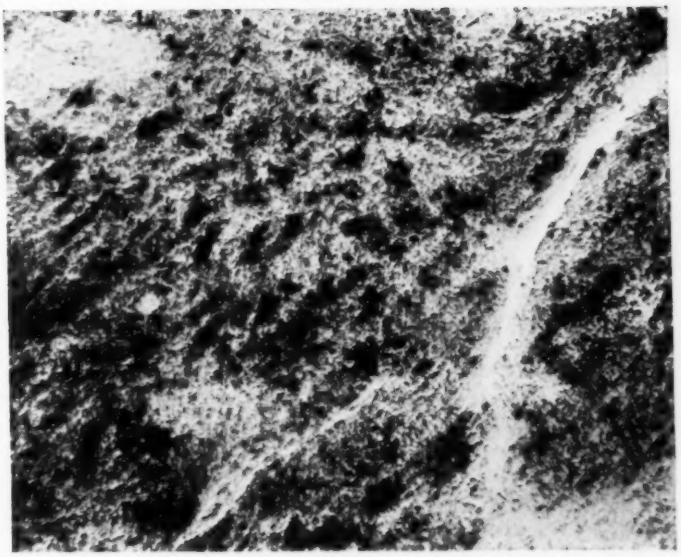


FIG. 22.—(Case 117155.) Photomicrograph of xanthic tumor showing lipoids, represented by the dark areas. x100.

FIG. 23.—(Case 62650.) Photomicrograph of xanthic tumor showing cholesterin crystals surrounded by xanthoma lipoid or foamy cells. x100.

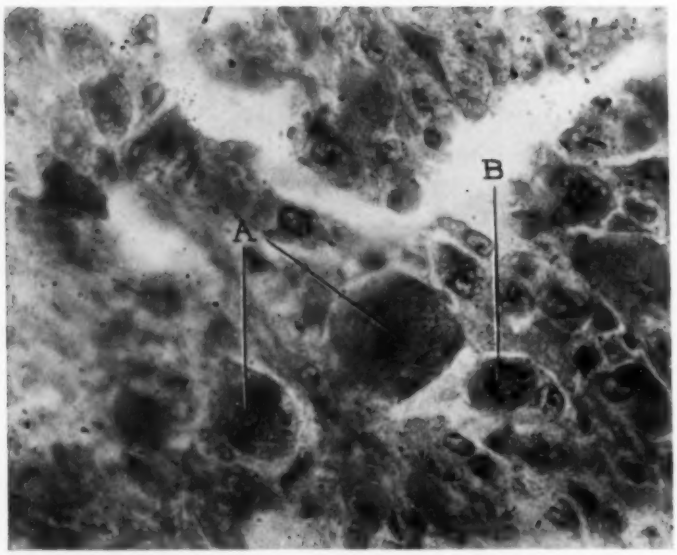


FIG. 24.—(Case 76189.) Photomicrograph of medullary sarcoma of the tibia containing tumor giant cells. (*A*) tumor giant cells, (*B*) mitotic figure. x500.

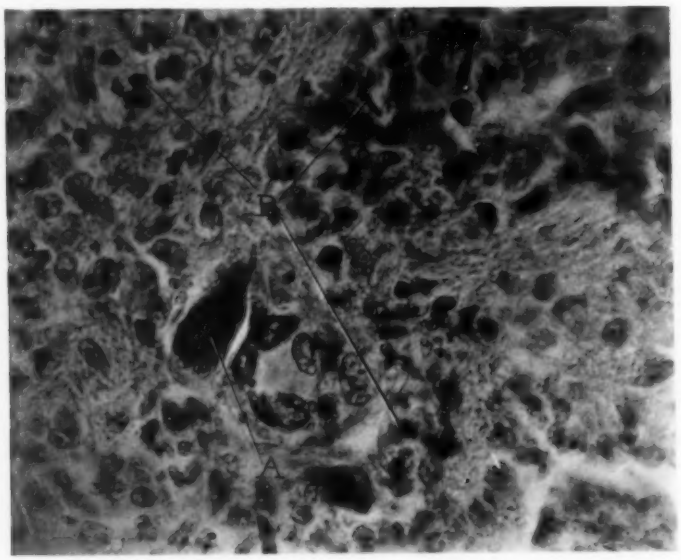


FIG. 25.—(Case 275800.) Photomicrograph of a rapidly growing medullary sarcoma of the femur containing foreign body giant cells. (*A*) foreign body giant cell, (*B*) mitotic figures. x200.

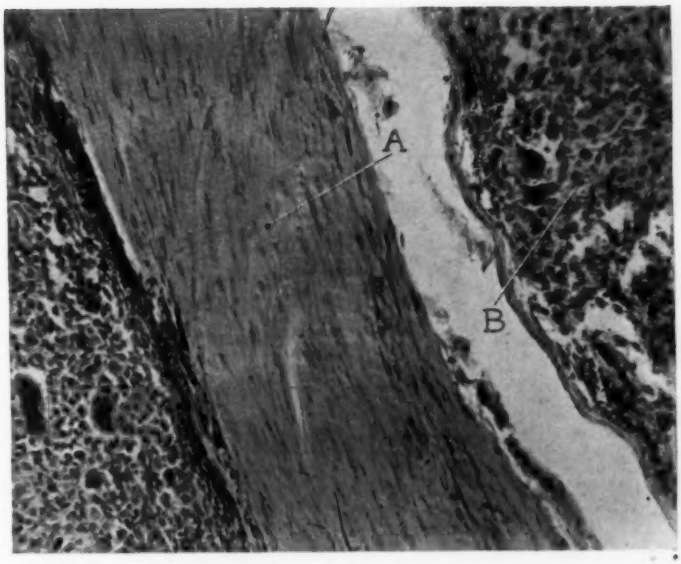


FIG. 26.—(Case 181836.) Photomicrograph of a xanthic tumor intimately connected with the tendon. (*A*) tendon, (*B*) tumor. x100.

One patient's leg was amputated three months after he left the clinic by his home physician, because the tumor had been diagnosed sarcoma and because the wound following local excision of the tumor failed to heal. The X-ray examination made at the clinic had shown some bone destruction. Seven years after amputation, however, there is no recurrence.

Macroscopic Findings.—Macroscopically the tumor appears as an encapsulated grayish or brownish or pinkish yellow lobulated mass. Whitish streaks of fibrous tissue connected with the capsule may be seen between the yellow areas. The tumor is of rather firm and tough consistency. It differs from the foreign body giant-cell tumor of the bone marrow and of the gum in that the latter tends toward a reddish tinge, closely resembling the color of grape juice, and in its tougher texture. Some of the foreign body giant-cell tumors of the bone marrow, however, are exactly like the yellow extraperiosteal tumors. A number of authors believe that the type of tumor I am discussing originates in the tendon sheath; as a matter of fact, 16 of the 17 tumors of this series were intimately connected either with the tendon sheath or with the tendon; one tumor, however, was located between the skin and the superficial fascia of the anterior aspect of the leg, about midway between the ankle and the knee. The tumors varied from 0.5 cm. to 8.7 cm. in diameter (Figs. 1, 2, 3, and 4).

Microscopic Findings.—Microscopically the xanthic tumor is divided into fibrous and cellular areas. Fibrous bands surround the cellular areas, dividing the tumor into lobules. In some of the tumors the fibrous areas form the bulk of tumor substance, and in others the cellular areas predominate. Bands of fibrous tissue may extend into the cellular areas. The fibrous areas contain a few cells of various descriptions.

In the cellular areas are small lymphocytes, fibroblasts, and a large number of medium sized cells with round and oval pale staining nuclei and very small nucleoli—probably endothelial cells. Some fields show a fairly large number of mononuclear phagocytes containing pigment and débris. Polymorphonuclear neutrophiles and mitotic figures are scarce.

All the tumors contain typical foreign body giant cells. In part of the tumors the giant cells reach as high as forty to the low power microscopic field, while in other areas of the same tumor only a few scattered cells can be seen. A few of the tumors show only a few scattered giant cells in any microscopic field. Some of these cells contain a small number of nuclei, while in others as many as one hundred have been counted. The nuclei, on the average, are slightly larger than the small lymphocytes and are round or oval with a fairly regular outline containing small nucleoli. They lie in an eosinophilic protoplasm and bear a striking resemblance to endothelial cells. Some of the giant cells are lying in apposition to blood pigment, while others are in direct contact with the surrounding cells or lie in open spaces. These giant cells are like those found in the medullary giant-cell tumor of bone and of the gum, and like the giant cells that collect around cholesterin crystals, blood pigment, non-

absorbable suture material, colloid, and cornified epithelium in cases of epithelioma, and like the giant cells that are associated with syphilis, leprosy, blastomycosis, coccidoidal granuloma, and tuberculosis. In the latter two conditions a number of the giant cells have peripherally arranged nuclei. The giant cells that are found in this tumor are also like the osteoclasts of normal bone.

Blood-vessels are rather numerous in different parts of the tumors, also blood spaces. Foamy, lipoid, or xanthoma cells are located mostly toward the periphery of the tumors, although a few can be seen in the centre. All the tumors contain lipoids demonstrated by staining with Scharlach R and by Ciaccio's method, some in large amounts, while in others very little may be seen. Only one showed cholesterin crystals and all showed a positive reaction to iron (Figs. 5–23).

DISCUSSION

In a consideration of xanthic tumors attention must be paid to the significance of the microscopic architecture from a physiologic standpoint. A striking feature noticed under the microscope is the presence of foreign body giant cells. MacCallum in discussing their origin states that Maximow "by the use of porous foreign bodies embedded in the tissues showed that lymphocytes which had wandered out from the blood-vessels appeared, as it were, in pure culture in the spaces of the foreign body, and subsequently grew and developed until, in their various stages, they became identical with all the forms of large mononuclear wandering cells with abundant protoplasm and phagocytic activity." . . . "Fusion of several such cells produces giant syncytium-like cells with many nuclei which are particularly able to engulf foreign bodies and are known as foreign body giant cells."

Mallory believes that the foreign body giant cells are formed by fusion of endothelial leucocytes. Of the origin of endothelial leucocytes, he says in his text-book: "They are derived from the endothelial cells lining blood, and to a less extent lymph, vessels by proliferation, and desquamation. They also multiply by mitosis after emigration from the vessels into the lesions." Mallory's conclusions in an article on giant-cell sarcoma are: "Giant cells of at least two different types occur in tumors. One type results in multiple mitosis and is a true tumor giant cell. It signifies rapid growth and may occur in a variety of different tumors.

"The second type is due to endothelial leucocytes invading tumors, especially those involving bone, and fusing to form foreign body giant cells. They are not tumor cells (although the tumors containing them are the ones which receive the name of giant-cell sarcoma) and usually signify only erosion and disintegration of bone. Tumors containing these giant cells should be classified according to the nature of the type cell from which they arise. The term giant-cell sarcoma should be discontinued."

Alveolar spaces are seen in the cellular areas filled with the various

kinds of cells I have described; these spaces show definite endothelial proliferation which makes them appear like blood sinuses. Blood pigment may be seen in these spaces as well as being scattered in patches throughout practically the whole of all of the tumors.

We know that the foreign body giant cell has a definite purpose in the tumor, namely, to absorb foreign material. This material may be blood pigment, cholesterin crystals, and other foreign substances. It is a well-known fact that the function of the osteoclast is to absorb bone, calcified cartilage, or anything that needs to be cleaned up; in other words, it is a "clean up cell." Morphologically the foreign body giant cell is like the osteoclast; since they are morphologically the same, the chances are that their functions are similar.

Before a new house can be constructed where an old one stands, the old one must first be burned or moved away whole or in parts. A similar process takes place in bone construction; the osteoclasts tear down and clean up and make way for the osteoblasts which are bone builders. All the normal cells of the normal organism have a definite function; not to know their function is ignorance on our part.

We have every reason to believe that it is the function of the foreign body giant cell to absorb foreign material, which is not only found in this tumor but in great numbers in the medullary giant-cell tumor of bones, and also in the giant-cell tumor of the gum. It is sometimes found in malignant tumors. It is called on to perform its function in various parts of the body, and because it looks like an osteoclast one must not assume that it is connected with bone, since it is found in places far removed from bone tissue.

The true tumor giant cell differs from the foreign body giant cell by having large irregular nuclei and often a mitotic figure (Fig. 24). The nature of the tumor must be judged by other cells and not by the foreign body giant cells (Fig. 25). One of the tumors in our series was rather extensive and had become attached to the tibia, fibula, and astragalus, causing some destruction of bone. The tumor was excised but the wound did not heal and the leg was amputated elsewhere three months later. This tumor caused the destruction of bone because it contained a large number of foreign body giant cells that were performing their normal function of destroying bone. Because a tumor containing foreign body giant cells destroys bone does not necessarily mean that the tumor is malignant. The same process takes place in the medullary giant-cell tumor of bone and in the giant-cell tumor of the gum.

Large mononuclear phagocytes are seen in a number of the microscopic fields. Foamy cells which are filled with a lipoid substance are present in 64.7 per cent. of the cases. Blood pigment is in evidence in almost every microscopic field. These findings naturally suggest that the process is a degenerative one. On the other hand, fibroblasts with an

abundance of fibrous tissue are quite numerous. In some fields blood-vessels as well as alveolar blood spaces are fairly numerous, the latter showing a marked endothelial proliferation. Cells that look like endothelial cells are quite numerous in all the cellular areas. Lymphocytes are frequently found in the fibrous tissue and in the cellular areas. When these facts are taken into consideration, the natural conclusion is that a constructive process is going on.

Injury seems to play an important part in the origin of xanthic tumors; 35.3 per cent. of our series of patients gave a definite history of injury. In two of the cases, the finger was cut and the growth started shortly afterward. In one the second toe swelled after a horse had stepped on the foot. In the case in which the leg was amputated elsewhere, a horse had fallen on the ankle, and the swelling which appeared remained permanently. Infection must also be considered a factor, as it may be possible that the tumor starts as the result of the extravasation of blood into the tissues, caused either by infection or by injury. Evidence of old hemorrhage is one of the constant findings.

The microscopic findings in bursitis and chronic tenosynovitis are similar to the findings in the xanthic extraperiosteal tumor, except that giant cells are only occasionally seen in the two former conditions in which the foamy or xanthoma cells, endothelial proliferation, fibroblasts, and blood pigment are also found. Foamy cells are likewise present in some hæmangiomas. Most writers believe that the xanthic tumor starts from the tendon sheath, but in one of our cases it was located between the skin and superficial fascia; all the others, however, were in close relationship to tendons (Fig. 26).

Bloodgood, in a recent article on medullary giant-cell tumor of the lower end of the ulna, said: "The more I study this group of local growths, the more convinced do I become that it belongs to a special type of angioma or granulation tissue tumor of which the xanthoma is a variety." He further states that, "The majority of tumors about the tendon sheaths contain giant cells and the stroma is not unlike the central giant-cell tumor of bone. . . . These tendon sheath tumors seem to have a distinct relation to trauma."

While the type of tumor under discussion has been pronounced malignant by some writers, it is regarded as benign by others. Fleissig called it a granuloma while Dunn expressed the view that it is on the border line between tumor growth and granulomatous formation.

It may be concluded, therefore, after thorough macroscopic and microscopic examination of seventeen of these tumors, and a consideration of the clinical history and ultimate result, that it is justifiable to call them benign growths, which are probably the result of the extravasation of blood following injury or infection, as they seem to have more of the microscopic features of a granulation tissue tumor than of a true neoplasm. Under no consideration should they be called sarcomas.

REFERENCES

Bell, E. T.: Ciaccio's method for the demonstration of lipoids. Jour. Med. Research, 1911, xxiv, 539–546.

Bellamy, H. F.: The myeloid tumors of tendon sheaths. Jour. Path. and Bacteriol., 1901, vii, 465–480.

Bloodgood, J. C.: Bone tumors. Central (medullary) giant-cell tumor (sarcoma) of lower end of ulna, with evidence that complete destruction of the bony shell or perforation of the bony shell is not a sign of increased malignancy. Ann. Surg., 1919, lxix, 345–359.

Dor, L.: Relations des tumeurs à myeloplaxes et des xanthomes. Cong. de chir., (proc. verb.), 1898, xii, 553–562.

Dunn: Quoted by Stewart, M. J., and Flint, E. R.

Ely, L. W.: Giant-cell growth of bone and tendon sheath. Giant-cell sarcoma, benign myeloma, etc. Ann. Surg., 1918, lxviii, 426–428.

Fleissig, J. Über die bisher als Riesenzellensarkome (Myelome) bezeichneten Granulationsgeschwülste der Sehnenscheiden. Deutsch. Ztschr. f. Chir., 1913, cxxii, 239–265.

Heurtaux, M. A.: Myélome des gaines tendineuses. Arch. gén. de méd., 1891, clxvii, 40–54; 160–169.

MacCallum, W. G.: A text-book of pathology. Philadelphia, Saunders, 1918, 1085 pp.

Mallory, F. B.: Giant-cell sarcoma. Jour. Med. Research, 1911, xxiv, 463–467.

Mallory, F. B.: The principles of pathologic histology. Philadelphia, Saunders, 1914, 677 pp.

Pybus, F. C.: A note on a case of myeloma of the tendon sheath. Brit. Jour. Surg., 1917–1918, v. 172–173.

Stewart, M. J., and Flint, E. R.: Observations on the myeloid tumour of tendon sheaths. Brit. Jour. Surg., 1915–1916, iii, 90–99.

Targett, J. H.: Giant-celled tumors of the integuments. Tr. Path. Soc. London, 1897, xlviii, 230–235.

Tourneux, J. P.: Les sarcomes des gaines tendineuses. Rev. de Chir., 1913, xlvii, 817–854.

GLIOMA OF THE BUTTOCK

By A. R. Kimpton, M.D.
of Boston, Mass.

The cases of glioma here to be reported are worthy of note because of their situation outside the central nervous system. It is very rare to find glioma so situated. Adami [1] gives four locations for glioma, as follows: 1. Brain; 2. certain cerebral nerves; 3. retina; 4. over the coccyx (evidently from remains of the neural canal). The retinal variety can be excluded from consideration, for Adami says that retinal gliomata are only in part formed of typical glial tissue. And Mallory [2] says that no one has yet shown by modern differential stains that gliomata of the retina occur. They should be called neuro-epitheliomata.

Dr. J. Payson Clark, in a report of two unusual cases of gliomata of the nose,[3] says: "There seems to be some difference of opinion, therefore, among writers on this subject, as to whether or not true glioma ever occurs outside the brain or spinal cord, but no writer denies that the appearance of this growth anywhere except in the regions just mentioned is very rare." Doctor Mallory [2] has well described the glioma as "a tumor consisting of proliferated neuroglia (the supporting tissue of the central nervous system) and of blood-vessels which are accompanied by a small amount of connective tissue." Glia or neuroglia is composed of cells and delicate fibrils. The cells show many fine processes radiating from the body in all directions, which give them a spider-like appearance.

Hugo Ribbert, in a recent article,[4] says that glioma may be formed of glia cells or may contain or be formed entirely of cells whose origin is earlier in the development of the central nervous system, which are then known as spongioblasts. Spongioblasts are concerned in the production of neuroglia, while neuroblasts give rise to the nerve cells. These spongioblast cells are differentiated from the normal glia cells in their size, evidence of their protoplasm, and their number, but always resemble them closely. Gliomata differ greatly among themselves. Some have spindle cells, others contain ganglion-like cells, and still others contain an abundance of fibrillar substance. Although the relation of the ependymal cells, which line the ventricles of the brain and the neural canal of the cord, to the neuroglia cells in post-embryonic life is undecided, a form of glioma of ependymal origin is recognized.[2] Growth of these ependymal cells results in the development of cells of glial type, whereby ependymal cysts appear as inclusions in tumors of gliomatous type.[1] Finally there are gliomata that are almost completely cellular, and contain but few fibres, and in this respect are of a sarcoma-like structure. It is this variety that have been described as glio-sarcomata. Ribbert is of the opinion that the term *sarcoma* should be reserved for connective-tissue

tumors, and prefers to speak of a richly cellular glioma as a glio-blastoma, which term includes both the slowly and rapidly growing types. The more cellular the tumor is the more rapidly it grows, whereas the more fibrillar tumors grow more slowly.

Macroscopically [5] gliomata vary from the size of a hazel nut to that of a fist, or rarely larger. They are of two varieties: hard, well-defined growths, or, more often, soft, diffuse, infiltrating growths with no trace of a capsule. The latter form extends by infiltration. A section through such a soft glioma may differ very little in color from the normal gray or white matter of the nervous system, but usually it is mixed with grayish-red gelatinous and hemorrhagic portions. It may manifest cystic degeneration.

Both the hard and soft growths are essentially benign in that they rarely, if ever, metastasize, but tend to recur locally. The retinal neoplasms which are believed to be included improperly under gliomata exhibit more evident signs of malignancy, which is an added argument for omitting them from this group. The injuries caused by glioma are not those of metastasis, but simply those of pressure, and of destruction of the nervous tissue, which the growth infiltrates. They may infiltrate the pia.

In the article already referred to Doctor Clark has reported two cases of glioma of the nose, and Oppenheim [5] has mentioned a remarkable case of a growth of the spinal cord which made its way through the vertebra towards the abdominal cavity. This, he says, happens rarely and under unusual circumstances. These are the only references that have been noted, in recent literature, of gliomata situated outside the central nervous system. Doubtless the cases that follow can be included under Adami's fourth group of gliomata "over the coccyx." Whether they can or not, these growths situated, as they are, outside the spinal cord are rare.

Case I.—*History.*—Baby boy, fourteen weeks old, first baby. Congenital cystic tumor of left buttock which becomes tense when baby cries. It has been increasing in size since birth (Fig. 1). X-ray showed no evidence of spina bifida. Nothing else abnormal about the baby.

Operation.—A semicircular incision was made over the tumor. Dissection was carried down to cyst, which was dissected out as far as possible; and was accidentally opened with the escape of a large amount of clear amber-colored fluid. The cyst extended upward in front of the vertebræ to the first lumbar vertebra. It had had apparently some connection with the spinal canal from the side of the coccyx and the anterior surface of the sacrum. On the inner side of the sac was a large red soft cellular infiltrating mass. The entire sac was apparently dissected or twisted out. The child made an uneventful recovery.

Post-operation History.—Fig. 2 shows a photograph of the child three and one-half years after operation. The child was normal

apparently in every way. On one occasion since operation there was a discharging sinus at the site of the operation, which lasted a short time. It is now four years since the operation and there is no evidence of return of the glioma.

Pathological Report.—"S15, 1854—9/20/15. Gross: 1. Flat piece of tissue 13 x 7 cm., evidently portion of opened up sac; part of external surface bears a small quantity of pale, finely lobulated fat and a small serous cyst; elsewhere surface smooth, inner surface trabeculated with shallow depressions; between the trabeculæ, color pink blue. Tissue varies in thickness 1-5 mm. 2. Three small, soft, flat, blue bits of tissue, one surface smooth, the other granular. 3. Cylindrical mass 3 x 1.3 cm. in diameter, gray-yellow, with dull red area, moderately firm, cut surface homogeneous gray.

"*Diagnosis:* Glioma."

F. B. MALLORY,
Pathologist.

CASE II.—*History.*—Baby girl. Fourteen weeks old. Normal baby except for large cystic tumor filling entire right buttock, which was present and had been increasing in size since birth. The outlines of this tumor were 11½ by 8 inches (Fig. 3). In the tumor there were areas of solid masses which felt like soft cartilage and seemed ready to slough through very soon. Because of experience with and similarity to Case I, a pre-operative diagnosis of glioma was made.

Operation.—An incision was made around the tumor mass and a cystic tumor was dissected out intact (Fig. 4). The tumor was adherent to the rectum for about 2½ inches. When the pedicle was freed, except for final attachment, it was found to come from the inner surface of the coccyx, the lower end of which was removed with the tumor. The tumor was dissected out with the greatest of ease.

Pathological Report.—"S16, 1977—12/6/16. Gross: Specimen consists of a fluctuant tumor mass 14 x 10 x 10 cm.; three-quarters of the tumor is covered with smooth soft epidermis. The remaining portion is rough and shows fatty tissue, muscle, and a portion of bone 1 x 1 cm. On opening the tumor it was found to be composed of two separate cysts filled with clear yellowish fluid. The smaller cyst measures 6 x 5 x 5 cm. and shows a slightly trabeculated grayish wall with numerous white pin-head-sized granulations. The wall is firm and of paper thickness. In places there is irregular brownish deposit on the surface of the wall which can be easily scraped off.

"*Diagnosis:* An ependymal glioma with cystic dilatation."

F. B. MALLORY,
Pathologist.

Post-operative History.—Unfortunately this child died on the third day from pneumonia, which, needless to say, was a great disappointment.

The first case was done under most adverse circumstances and with considerable difficulty, yet recovered, while the second case done under most perfect circumstances, and with the greatest ease, died.

FIG. 1.—Case I. Glioma of buttock. Baby boy, fourteen weeks old.

FIG. 2.—Case I, three and one-half years after operation.

FIG. 3.—Case II. Glioma of buttock. Baby girl, fourteen weeks old.

FIG. 4.—Case II. The glioma removed. 4 x 10 x 10 cm.

REFERENCES

J. G. Adami: The Principles of Pathology. General Pathology, vol. i, Lea & Febiger, Phila. and N. Y., 1910, pp. 756–758.

[2] F. B. Mallory: Reference Handbook of Medical Sciences, vol. iv, Wm. Wood & Co., N. Y., 1902, pp. 378–383.

[3] J. P. Clark: Glioma of the Nose, American Jour. of the Med. Sciences, vol. cxxix, New Series, Lea Bros. & Co., Phila. and N. Y., May, 1905, pp. 769–774.

[4] Hugo Ribbert: Ueber das Spongioblastom und das gliom, Band ccxxv, pp. 769–774. Virchow's Arch. f. path. Anat., Berlin, 1918, pp 195–213.

[5] H. Oppenheim: Text-Book of Nervous Diseases, translated by A. Bruce. G. E. Stechert & Co., N. Y., 1911, pp. 887, 888.

EXPERIMENTAL RESECTION OF THE DOG'S KNEE JOINT*

(SECOND STUDY)

By Leonard W. Ely, M.D.
of San Francisco, Cal.

This study is supplemental to one made some years ago in collaboration with Dr. John Francis Cowan.[1] The results of that study indicated the advisability of carrying the experiments along for a greater length of time.

Morphine was administered before operation. The animals were anæsthetized with ether. The skin was shaved, and was washed with soap and water, then with bichloride of mercury solution, then with alcohol. Strict asepsis was observed.

The incision was through the patellar tendon, the customary one, convex distally. The flap was retracted proximally, and the joint was opened. Varying amounts of bone were removed in the various experiments, in order to observe in this series, as in the other, whether the amount of bone removed influenced the resulting union. In some the section was in the form of a mortise. The capsule was then sutured as firmly as possible. The skin suture followed, and a sterile dressing was applied. The limb was put up in a plaster of Paris spica. Only one infection occurred, dog 37.

The animals were sacrificed or died in periods from 14 days to 1103 days—three years and one week.

After death the joints were removed, and fixed in alcohol or liquor formaldehyde. Sagittal sections were then cut, decalcified, run through the alcohols and ether, imbedded in celloidin or a substitute, and stained with hæmatoxylin and eosin, and with the van Gieson stain.

The protocol of the experiments follows:

Dog 23 (975 days).—November 18, 1915: Resection of right knee. Rather young, medium-sized female. Curved incision, dividing patellar tendon. Removal of patella. Catgut suture, skin partly with silk. Removal of 17 mm. from femur and 8 mm. from tibia. This is a large amount for this size dog. Plaster spica down to toes.

December 11, 1915: Dressings removed on account of foulness. Not replaced. Stitches removed.

December 31, 1915: The animal gave birth to six puppies, four were dead, two alive.

March 15, 1916: Dog in good condition. Resected joint, slightly large, has a range of motion beween 140°–180°, painless. Uses leg very little.

July 7, 1916: Uses leg a little. The knee, fairly stable, is held in extension, and has about 30° of motion.

January 23, 1917: Very little motion.

---

* From the Stanford University Laboratory of Surgical Pathology.

[1] Bone and Joint Studies, I. Leonard W. Ely and John Francis Cowan. Stanford University, Calif. Published by the University, 1916.

July 20, 1918: Died last night. The joint is stiff and much increased in size. Joint into alcohol.

Section reveals that a very firm union is present between the two bones, which form an angle of about 150°, but not a bony union. It yields very slightly to force, and the line of division between the bones can be made out distinctly. The femur presents an unusual appearance, namely, what appears to be a tongue of fibrous tissue extending upward from the head of the tibia divides it in two, an anterior or larger part and a posterior or smaller. This is no artefact. (Does the anterior represent the original femur end, and is the posterior part new bone, built up to buttress?) The tibial head seems somewhat increased antero-posteriorly, and has slipped backward on the femur. It is this perhaps which is responsible for the increase in size of the joint antero-posteriorly.

Histology.—The femur articulates with the anterior portion of the tibia. The posterior portion of the tibial head projects backward. In other words, the head of the tibia is much broader than the femur. Whether this disparity in size was caused by the operation or by the building up of new bone on the tibia is hard to say; probably the former, for the tibia looks approximately normal in shape. A mass of new bone has also been built up on the posterior aspect of the extreme lower end of the femur, and this is separated from the tibia by a very dense fibrous tissue. The bones are bound together by fibrous tissue in which are many cartilage cells—fibrocartilage. Their anterior and posterior portions are fairly close together, but the end of each bone is more or less concave, the femur decidedly so, and the space left by this double concavity is filled with a loose meshed fibrous tissue, quite vascular. Anteriorly and posteriorly the bones are bound together by dense fibrous tissue, in which are cartilage cells. In the anterior fibrous tissue is a small irregular cleft, evidently the remains of the old joint, lined by a tissue resembling synovial membrane, but not to be identified positively. In the posterior fibrous tissue is also a transverse cleft, more or less distinct in the various slides. The marrow in both bones is lymphoid and fatty, the fatty predominating near the joint. Many osteoclasts are seen, but few in Howship's lacunæ.

Recapitulation.—Rather close union of the bones by fibrous tissue and fibrocartilage, in which are small transverse clefts.

Dog 24 (694 days).—December 2, 1915: Resection of right knee. Medium to small size, rather young, female. Removal of about 2.5 cm. altogether from both knees, moderate amount. Mortise operation. Suture in two layers. Wound painted with Canada balsam; plaster spica applied.

January 20, 1916: Dressings removed. Wound healed normally.

March 15, 1916: Dog uses leg fairly well. Resected joint very stiff, slightly enlarged, possesses some lateral as well as some antero-posterior motion.

July 7, 1916: Knee in extension and very stiff. Animal uses leg well.

January 25, 1917: Firm union in extension.

October 26, 1917: Animal died to-day. Right knee-joint removed and placed in 95 per cent. alcohol. Absolute stiffness.

August 6, 1918: Specimen sawed sagittally. Bony union has taken place, and the site of the former joint cannot be determined. The marrow of the femur is red, and the bone is spongy. The marrow of the tibia is yellow, except very close to the site of the former joint, where it is red. Just distal to this small area of red marrow in the tibia the bone seems rather dense.

Histology.—Complete bony union, spongy bone at site of old joint, whose trabeculæ are continuous. Location of old joint is indicated by a projection of the bone posteriorly. Cortex rather thin. No evidence of canalisation or thickening of cortex. No evidence of activity either in the sense of bone destruction or bone production. Fatty marrow exclusively.

Recapitulation.—Bony union.

Dog 25 (14 days).—December 9, 1915: Resection of right knee. Medium size

female. Removal of *small pieces* of bone from tibia and femur—from femur, 9 mm.; from tibia, 7 mm. Patella left in. Wound sutured with catgut. Canada balsam painted on. Gauze dressing. Plaster of Paris.

December 9, 1915: At 5.15 P.M., plaster dressing torn off. Replaced.

December 10, 1915: At 9 A.M., plaster dressing again off, and very carefully and slowly reinforced with good plaster. A hypodermic of morphine was given each time the dressing was reapplied.

December 20, 1915: Dressings removed. Wound dry and healing by first intention.

December 23, 1915: Gave birth to one pup. The animal is very ill.

December 24, 1915: The animal died last night. Unable to give birth to young or to "clean"—retention of decidua.

December 24, 1915: Autopsy.

Wound has healed *per primam*. Joint, freely movable, removed and put into 90 per cent. alcohol.

Joint sawed sagittally. The end of the femur fits fairly well into the tibia, and a cavity exists between the two bones.

The bones are bound loosely together, with a space between them, which communicates with the quadriceps pouch anteriorly. The cortical layer is irregular in both bones.

Histology. The Tibia.—The posterior part of the cut surface consists of fibrous connective tissue, which gives place a little way out to a layer of fibrin. This continues about half way across the joint, then ceases, and the anterior half of the surface is bare bone, rather ragged, and to a great extent appearing new-formed, to shut off the marrow from the joint cavity.

The marrow in the vicinity is fibrous and lymphoid, and the bone shows well-marked evidence of typical rarefying osteitis, *i.e.*, osteoclasts in Howship's lacunæ. The blood sinuses are engorged, as with animals dying of infectious disease. Near the joint a break exists in the cortex, through which the fibrous tissue on the outside is directly continuous with the marrow. Adjoining this is an island of cartilage, and then comes a stretch where a mass of marrow tissue lies directly beneath the periosteum. Farther still from the joint one sees the formation of cancellous bone beginning on the outside of the cortex, evidently being formed from the periosteum, and at the end of this the cortex on its outer aspect is apparently being hollowed out in places by osteoclasts, as if in an effort at its remodeling. Still farther from the joint many small cells with deeply staining nuclei (what we are wont to call osteoblasts) lie upon the cortex, with here and there a typical osteoclast. Here the periosteum consists of two distinct layers, a thin outer one, composed of dense fibrous tissue, and a much broader inner one, of looser fibrous tissue, whose fibres run diagonally between the femur and the bone.

Anteriorly.—The whole cortex evidently is being remodeled. It is ragged in outline, and has lost its solid, dense appearance, beginning to take on the appearance of cancellous bone. Many osteoclasts are present in Howship's lacunæ, and apparently the bone is being converted into fibrous tissue. The marrow is partly lymphoid, partly fatty and delicately fibrous. It contains many blood-vessels. Outside the cortex and communicating with its trabeculæ new bone is being formed from fibrous tissue.

The Femur.—The cut end of the femur is covered for the most part by fibrin, though in places bare bone is at the surface. There is practically no fibrin over the bone tissue itself, but it is present where otherwise marrow would be at the surface. Not so complete a bony wall is present against the joint as in the tibia. The marrow in the immediate vicinity is delicately fibrous, and the bone shows marked rarefying osteitis. Farther away from the joint the marrow is lymphoid. Throughout it shows the engorgement peculiar to animals dying of infectious disease.

Anteriorly and posteriorly one sees the beginning of bone formation on the outside of the cortex in the periosteum, though not in so marked a degree as in the tibia.

The joint shows the remains of hemorrhage into it, and the synovial membrane is thickened, infiltrated and villous.

Recapitulation.—Joint lined by fibrin and bare bone. Active remodeling of bone ends. Bone developing in the periosteum.

Dog 26 (17 days).—December 16, 1915. Resection of right knee. Curved incision dividing *lig. patellæ*. Removal of *large pieces* of bone—2 cm. from femur and 12 mm. from tibia. Catgut sutures. Plaster spica.

January 2, 1916: Died. Autopsy showed pneumonia as the cause of death. Wound healed practically *per primam*. Knee-joint movable, flexion somewhat limited. Joint sawed sagittally. The bone ends are rough, and the tibia is displaced slightly backward. The bones are tied loosely together anteriorly and posteriorly, and the femur has slipped forward on the tibia.

Histology.—The joint contains the remains of hemorrhage. Fibrin has been deposited upon the bone ends and is becoming organized, shutting off the marrow from the joint cavity, but no bone production has started here. Marked rarefying osteitis is present in the marrow in the vicinity. It is also quite active in and outside of the cortex of the tibia.

New bone formation has begun outside the cortex of both bones.

In other words, the architecture of the bones is being remodelled.

Owing to the failure of the nuclear stain to take hold, finer details in cell structure cannot be determined.

Recapitulation.—No visible effort at union of bones. Bone formation beginning.

Dog 27 (473 days).—December 23, 1915: Resection of right knee by usual curved incision through patellar tendon, removing a very large mortise from both bones. The femoral fragment was 27 mm. in thickness in its largest place, and the tibial about 15 mm. The femoral vein was wounded and tied. Wound in capsule and skin sewed up with catgut. Balsam dressing. Plaster spica.

December 30, 1915: Dog has been gnawing at the plaster since the operation. Dressing entirely removed.

March 15, 1916: Dog uses leg very little. Free motion is present, practically in normal limits, and some lateral motion. Fine crepitus is present in the joint.

July 7, 1916: Knee in about right-angle flexion. Motion quite free and accompanied by some grating of the ends of the bones. Dog uses leg very little.

January 25, 1917: Joint in semiflexion. It possesses a fair range of motion, and some lateral motion.

April 10, 1917: Animal killed by etherization. Joint placed in 95 per cent. alcohol. The normal knee removed also for comparison.

April 11, 1917: Knee sawed sagittally. The bones articulate at a lateral angle, so that the sawing is not satisfactory. The joint is in flexion and has quite a range of motion.

The femur fits into a concavity in the upper end of the tibia, and between them is a distinct cavity permitting motion.

The saw has caught the femur, but not the tibia. The femur terminates in a blunt point anteriorly, its posterior border rounding convexly downward to join the anterior at the point. It is this lower posterior border, as appears from the specimen, which articulates with the concave upper border of the tibia. The upper border of the tibia is prolonged upward posteriorly to assist in the reception of the femur.

Histology.—The marrow canal of the femur, in which appear a few small trabeculæ, is prolonged almost to the end of the bone. Its cortex consists of a layer of dense bone exteriorly, and beneath this of a somewhat thicker layer of rather dense spongy bone. A well-marked layer of dense bone continues around the distal extremity, covered by dense fibrous tissue, whose surface *has an appearance* typical of a synovial membrane. What evidently was an intra-articular ligament joins this fibrous tissue at

a short distance from the lower extremity of the bone, dividing off the joint into two compartments, an anterior and a posterior.

Both compartments are lined by a synovial membrane with beautiful synovial villi. No cartilage cells are to be seen in the tissue covering the femur.

A small exostosis is present on the posterior part of the cortex near the distal extremity.

The marrow is quite vascular, mostly delicately fibrous, but with considerable lymphoid elements in the spongy part of the cortex.

Recapitulation.—No ankylosis in spite of a mortise operation. Formation of new joint, but, as this was not exposed to pressure, no formation of cartilage. New synovial membrane covering bone end.

Dog 28 (374 days).—January 27, 1916: Resection of left knee, removing small pieces of bone, 6 mm. from condyles, 4 mm. from head of tibia. Part of the crucial ligaments was left, and the bones were fairly stable when brought into extension. Catgut sutures. Canada balsam, and gauze dressing. Plaster of Paris spica.

February 7, 1916: Removal of dressings on account of irritation.

March 15, 1916: The dog uses leg very little. The joint possesses free range of motion, between complete flexion and about 150° extension. The joint grates on motion.

July 7, 1916: The dog uses leg fairly well. Knee is freely movable, and, except for slight lateral motion, is stable.

January 25, 1917: Practically normal.

February 5, 1917: The dog was badly chewed up by another dog two days ago, without injuring the knee. Died last night. Joint removed.

February 24, 1917: Joint sawed sagittally. The bones are bound rather firmly together by fibrous tissue, but the joint is in semiflexion and the sharp posterior corner of the end of the femur is applied at about the middle of the tibial head.

The bones are not bound together directly, but are separated by fibrous tissue in denser and lighter bundles and masses which do not pass from bone to bone, but from the end of each bone run laterally to join the ligament. This fibrous tissue contains many small spaces. The fibrous tissue close to the two bones contains many cartilage cells, more on the tibial side than on the femoral. Posteriorly is seen a large, irregular space lined by necrotic tissue, and just posterior to this space is a horn of bone sticking up from the posterior part of the tibia, probably left behind at the resection. This horn of bone is covered posteriorly by hyaline cartilage in good condition and evidently entering into the formation of a bursa. It is capped by fibrocartilage, from which fibres, joined by others from the posterior ligament, run forward between the tibia and femur. Running up from the tibial marrow into the fibrocartilage over it are capillary loops, but no active bone formation is seen there. The processes of change of architecture in both bone ends seems at an end. There is no increase in blood-vessels, no evidence of osteoclasis, no typical productive osteitis. The marrow in both bones and in the patella is fatty. The cartilage on the patella and that on the anterior surface of the femur are in good condition, and the joint space between them can be traced distalwards for some distance into the fibrous tissue as an irregular synovial cavity, lined with typical synovial membrane. This synovial cavity, while in the mounted position of the bones in the specimen lying distal to the anterior part of the joint surface of the femur, does not extend at all over the tibia, on account of the subluxation backward of the latter. Proximally also the synovial cavity can be traced well up the femur.

Recapitulation.—Bones bound together by fibrous tissue and fibrocartilage with clefts allowing some motion. No new joint. Persistence of femoro-patellar joint cavity.

Dog 29 (3 years, 1 week—1103 days).—February 3, 1916: Resection of right knee, removing *large* pieces of bone. The animal evidently was a puppy of about three months. Usual curved incision through patellar tendon. Piece of femur removed, 18 mm. Piece of tibia removed, 1 cm. Patella removed also. Catgut sutures. Canada balsam and gauze dressing. Plaster of Paris.

FIG. 1.—Normal dog's knee.

FIG. 2.—Dog 23.

FIG. 3.—Dog 24.

FIG. 4.—Dog 25.

FIG. 5.—Dog 26.

FIG. 6.—Dog 27.

FIG 7.—Dog 28.—30 u.

FIG. 8.—Dog 29.

FIG. 9.—Dog 30.

FIG. 10.—Dog 31.

FIG. 11.—Dog 32.

FIG. 12.—Dog 33.

FIG. 13.—Dog 34.

FIG. 14.—Dog 35.

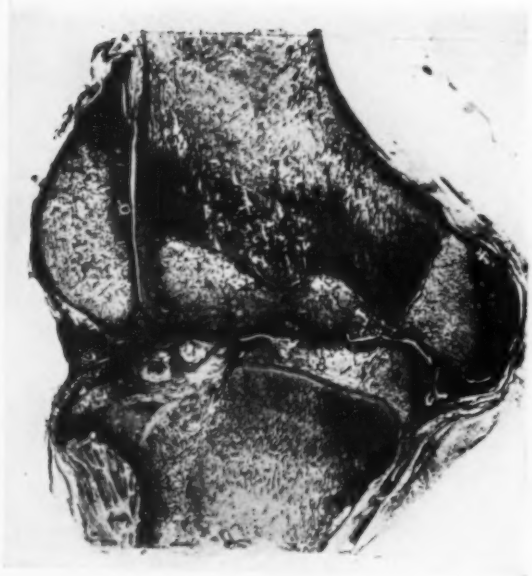


FIG. 15.—Dog 36.—No. 5.

FIG. 16.—Dog 37.

February 15, 1916: Dressings removed, as the animal was whining. Wound o. k.

March 15, 1916: The dog uses leg very little. The knee has 30°–40° of motion and some lateral mobility. The end of femur seems enlarged.

January 5, 1917: Joint in semiflexion, with a small amount of motion, some lateral.

February 10, 1919. Dog goes on three legs, and will not use the operated one. The knee has a considerable range of motion, is stabile, and apparently is not at all sensitive. Killed by illuminating gas. Joint removed. It has about 20° of motion.

February 14, 1919: Sagittal section of joint. Small amount of motion between the two bones. The femur gives the impression of being received into the head of the tibia, and its head is soft in its interior and dark in color, as if from hemorrhage.

The two bones articulate at an angle of about 150°, and the end of the tibia may be said to be irregularly concave to receive the end of the femur.

Histology.—The bones are bound together by fibrous tissue, and this fibrous tissue communicates directly with a mass of fibrous tissue in the femur end, without any bone tissue between them. The tibia, on the contrary, has bone at its end, in places fairly dense, in places more spongy. In the fibrous tissue over the tibia and close to the bone are numbers of cartilage cells, but only in certain areas. The fibres do not run across from side to side, but springing from the end of the tibia they run at first more or less at right angles to the old joint line, and then turn and run generally transverse. In the fibrous tissue is an irregular transverse cleft, running across most of the distance between the two bones—an irregular joint cavity, so to speak, not lined with synovial membrane, but with fibrin. A long streak of this fibrin runs up into the fibrous tissue in the head of the femur. Posterior to this, in the reëntrant angle between the two bones, is another irregular cavity or set of cavities lined by a tissue which looks much like a synovial membrane. Anterior to the large cleft, and running at first transversely, over the end of the femur and then longitudinally in front of it, is a narrow cavity, subdivided, or a set of narrow cavities, lined by tissue with an appearance of synovial membrane, and evidently representing the remains of the old quadriceps pouch.

The fibrous tissue in the head of the femur contains near the large cleft a network of large dilated blood-vessels with thin walls. Passing upward toward the shaft these larger vessels cease, and their place is taken by innumerable minute vessels engorged with blood. The cavity noted above in the gross examination consists largely of these. Passing further toward the shaft we come to more dense fibrous tissue, with well-marked blood-vessels, then to a region of spongy bone with lymphoid and fatty marrow, and then to the fatty marrow of the central canal.

The cortex of the bone about the cavity is composed of spongy bone, of different degrees of density, and on the trabeculæ are many typical so-called "osteoclasts," some of them in Howship's lacunæ. The osteoclasts are especially marked outside of the cortex under the quadriceps pouch on the anterior surface of the femur, though, of course, separated from the pouch by a layer of fibrous tissue.

The bone in the tibial fragment is much denser than that in the femoral, the marrow is delicately fibrous for the most part, with dilated and engorged blood-vessels, though farther from the end lymphoid and fatty marrow replace it. Typical osteoclasts are seen here also, but not in so great numbers as in the femur.

Recapitulation.—Bones bound together by fibrous tissue containing cartilage cells. Transverse cleft in this fibrous tissue not lined by cartilage or synovial membrane.

Dog 30 (24 days).—February 10, 1916: Dog is evidently *less than six months old.* Usual incision. Removal of *small* pieces of bone. Patella left in. The bone was very vascular, and the epiphysis contained a good deal of cartilage. Seven mm. removed from femur, 5 mm. from tibia. Plaster spica.

February 22, 1916: Plaster removed. Wounds healed *per primam,* except for one small area of the joint incision. No sign of any deep infection.

March 5, 1916: Died of diarrhœa. A few degrees of motion in knee. It is very stiff. The joint seems enlarged. Joint, not opened, into alcohol.

April 5, 1917: Joint sawed sagittally. The bone cuts easily and can be crushed between the fingers. The femur fits snugly into the tibia.

The bones are bound together by fibrous tissue at their circumference, and between them is a large irregular joint cavity. The front of the tibia is prolonged upward into a prominence, which, as there is no note of its being left at operation, is presumably new-formed. A closer inspection reveals the fact that the large joint cavity is probably an artefact. The bones evidently have been torn apart post-mortem. A convexity on the surface of one corresponds to a concavity on the other, and the reverse. Evidently in life the two were locked close together. The femoral fragment is received into a concavity formed by the tibia and fibula.

Histology.—The ends of both bones are, in fact, concave. The cut end of the tibia is covered by young connective tissue. The cut end of the femur shows bare bone in the anterior portion for a short distance. The rest is covered by young connective tissue, with small patches of organizing fibrin here and there. This young connective tissue fills the concavity in the end of the bone, like a plug. Anteriorly and posteriorly a few cartilage cells can be seen near the bone, deep in the connective tissue. The synovial membrane is villous, and has long ribbons of fibrin attached to it.

The trabeculæ in both bones are rather dense, and, at the bottom of the concavity in each, they seem to be undergoing absorption, but not by rarefying osteitis. They appear to be undergoing transformation into the fibrous tissue by which they are surrounded. The marrow is delicately fibrous and very vascular.

Recapitulation.—No union, except by periosteum.

Dog 31 (922 days).—February 17, 1916: Removal of large pieces of bone. Usual resection of right knee. Two cm. removed from femur, 8 mm. removed from tibia. Patella removed also. Catgut. Canada balsam dressing. Plaster of Paris spica.

March 15, 1916: Still wearing plaster.

March 21, 1916: Plaster dressing removed.

July 7, 1916: Uses leg fairly well. Scar on front of knee, depressed and attached to bone, joint very stiff.

January 25, 1917: Knee stiff in slight flexion.

August 27, 1918: Dog died.

August 28, 1918: Autopsy. Knee quite stiff.

October 25, 1918: Specimen sawed sagittally. Firm bony union has taken place, and the line of junction is not to be made out exactly.

May, 1919: Inspection of the stained slide reveals the line of union very distinctly, as a band, apparently of dense fibrous tissue extending almost across the bone. In the middle, however, the trabeculæ of the tibia and femur are continuous.

Histology.—The trabeculæ are continuous in the middle. The band of tissue is composed of fibrous tissue anteriorly, but posteriorly it is fibrocartilage. Between the fibrous tissue and the old subcartilaginous buttress of bone on the head of the tibia is a short slit, with undifferentiated walls, evidently the remains of the old joint cavity. Elsewhere the fibres pass across from bone to bone. No bone cortex is present anteriorly, but posteriorly a small bridge exists. From this bridge the fibres of the fibrocartilage spread out fan-shaped, sweeping inward to be joined by other fibres from the femur to be inserted into the tibia. The marrow is mostly fatty, some fibrous, and in the immediate neighborhood of the joint some amorphous, granular, containing spicules of bone, and presenting the same appearance as sometimes the marrow does in the second type of chronic arthritis ("arthritis deformans," hypertrophic arthritis). Apparently the process is at an end.

Recapitulation.—Bony union with remains of fibrous and fibro-cartilaginous union.

Dog 32 (720 days).—February 24, 1916: Resection of right knee. Removal of rather large mortise (about 3 cm.). Patella removed. Two layers of catgut sutures. Plaster spica.

March 15, 1916: Wearing plaster in good condition.

March 20, 1916: Plaster dressing removed.

July 7, 1916: Knee in extension and very stiff, feels like bony union. Animal uses leg in walking.

January 25, 1917: Leg very stiff in extension.

February 14, 1918: Dog killed under ether. Joint absolutely rigid.

August 6, 1918: The joint seems broadened, both antero-posteriorly and laterally, but this may be only apparent. It is quite stiff. Sawed sagittally. Bony union has taken place, and the site of the former joint cannot be determined. The trabeculæ are everywhere continuous between the two bones, and about 2 cm. of spongy bone intervenes between the two marrow canals.

Histology.—Bony union is complete. The old line of junction can only be told by the projection backward representing the old head of the tibia. A fairly thick cortex is present anteriorly, a thinner one posteriorly. The marrow is fatty. No sign of activity is present, no osteoclasis, even in the posterior spur, which should be doomed to disappearance, if our ideas on Wolff's law are correct.

Recapitulation.—Bony union.

Dog 33 (930 days).—March 2, 1916: Resection of right knee. Removal of small slices from femur and tibia with scroll saw, convex antero-posteriorly on femur, concave antero-posteriorly on tibia. Removal of the cartilage also well behind the condyles, and fairly well up on the anterior surface of the femur—a mere shell. Patella removed also. Four mm. from femur, 1 cm. from tibia in thickest part. Two layers of catgut sutures. Canada balsam, gauze, plaster of Paris spica.

March 15, 1916: Wearing plaster, which is excoriating. Plaster removed. It was soft, and the immobilisation had not been complete. The joint is stiff, but has a few degrees of motion. Plaster reapplied.

March 23, 1916: Plaster dressing removed.

July 7, 1916: Hair grown over scar. Leg very stiff, almost in full extension. A few degrees of motion are present. Animal uses limb fairly well.

January 27, 1917: Knee practically stiff in extension.

September 8, 1918: Death from tetanus. Knee stiff—apparently complete ankylosis. The joint is increased in size antero-posteriorly.

October 28, 1918: Sectioned sagittally. The femur has slipped posteriorly on the tibia and is received into a more or less cup-shaped cavity. The union of the two bones is very close, but not osseous. Specimen into alcohol.

Histology.—A narrow band of dense fibrous and fibrocartilaginous tissue, ranging from 1 to 2 millimetres in width, separates the two bones in an irregular line. Close to the bone, especially on the tibial side, new bone appears to be forming in this tissue. Several slits appear in it, with undifferentiated walls, but nothing resembling a joint cavity is seen. The fibres of this tissue run generally transversely, anteriorly and posteriorly, but in the middle they unite the bones directly.

The marrow is lymphoid and fatty, and its sinuses are somewhat engorged.

Recapitulation.—Close union by fibrous and fibrocartilaginous tissue.

Dog 34 (27 days).—March 23, 1916: Resection of right knee, as in preceding, removing a slice with scroll saw from the femur, convex antero-posteriorly, and another from the tibia, concave antero-posteriorly. Patella removed also. From femur a small piece, from tibia a small piece. The femur fragment was but a shell. Careful removal of the cartilage on the posterior surface of the condyles was carried out, and also on the anterior surface well up to the top of the quadriceps pouch. The bones were then apposed carefully, the posterior ligament was reefed, so as to bring them tightly together, and then the anterior and lateral ligaments carefully sutured, all with catgut. The result was a fairly firm and stabile union. Superficial sutures. Canada balsam. Plaster of Paris spica.

April 7, 1916: Plaster galls in opposite groin. Removed body portion, leaving the thigh and leg encased.

April 13, 1916: Remainder of plaster removed.

April 20, 1916: Died last night. Cause, dysentery. Motion in joint about 10°. Wound healed normally.

February 23, 1917: Joint sawed sagittally. Apparently very firm fibrous union.

Histology.—The bones are in close apposition anteriorly, and the periosteum passes across from the one to the other without a break, reinforced strongly by fibres springing from the head of each bone. Posterior to this, the spongy bone of the tibia and femur opens out into a very vascular fibrous tissue, containing much fibrin, and on the femur side, ossification appears to be taking place. It looks as if bony union eventually would have resulted. More posteriorly, the bones are separated by an irregular cavity, first lined by necrotic tissue, then consisting of a mere slit between them. Here the tibia presents rather dense bare bone, while the femur is covered by fibrocartilage. This slit continues a very short distance, and then widens out into a small cavity again, similar to the anterior one. Posteriorly the bones are separated, not joined, by a plug of fibrous tissue, whose fibres run in from the posterior ligament. This condition is quite different from that in the anterior portion, where the fibres pass across from bone to bone, uniting instead of dividing. No synovial membrane can be seen. The marrow is lymphoid. The epiphysial cartilages still are present.

Recapitulation.—Close fibrous union anteriorly, remains of joint cavity in the middle. Separation by fibrous tissue posteriorly.

Dog 35 (790 days).—May 12, 1916: Resection of right knee. Removal of moderate amount of bone—mortise operation. The cartilage was removed also from the front of the femur well up in the quadriceps pouch. A total of about 2 cm. was removed from the two bones, in about equal amounts. Patella also removed. Capsule sutured anteriorly and posteriorly. Skin with second layer. Balsam. Dry gauze. Plaster of Paris dressing in good extension.

May 26, 1916: Dressing removed.

July 7, 1916: Knee is fairly movable and wobbly on account of lateral mobility. Does not use leg.

January 25, 1917: Leg in semiflexion. Fair degree of motion, some lateral.

July 11, 1918: Dog died of nervous disorder. Joint very wobbly and with marked lateral mobility.

August 6, 1918: Joint sectioned sagittally. The tibia is flexed on the tibia at an angle of about 150°. The bones are separated by a band of what appears to be fibrous tissue about 3 mm. in thickness, and in this is a cleft running almost across the site of the former joint.

NOTE.—What appears to be a division of the head of the tibia by a mass of fibrous tissue, is an artefact, occasioned by the passage of the saw too near the side of the bone.

Histology.—The two bones are bound together at an angle of about 150° by dense fibrous tissue containing cartilage cells. In this fibrous tissue is an irregular, transverse cleft containing detritus. No synovial membrane can be seen except in the continuation of the cleft, in front of the femur, and occasionally on what looks like a small villus cut across in the transverse cleft. Somewhat more posteriorly and a little closer to the tibia is another cleft, rudimentary, with walls of fibrous tissue. A buttress of bone on the end of each bone separates its interior from the fibrous tissue.

The marrow in both bones is fatty. No evidence of rarefying osteitis is present. Apparently the changes have come to an end.

Recapitulation.—Free motion. Formation of new joint lined by fibrocartilage.

Dog 36 (150 days).—April 13, 1916: Resection of right knee, removing very large pieces—23 mm. from femur, 16 mm. from tibia—enough to get beyond the joint enlargement of the bones. Popliteal artery wounded and tied. Usual dressings. Plaster spica.

April 28, 1916: Removed dressing. Wound o. k.

July 7, 1916: Animal uses leg very little. Joint very movable. On account of lateral mobility it is very unstable. Grating of bones very marked.

September 11, 1916: Killed by the other dogs yesterday, but apparently without injury to joint. The operated joint is very loose, and grates when the bones are moved on each other. The lower inch of the femur is enlarged. The capsule is very loose.

February 24, 1917: Joint sawed sagittally. The bones are held very loosely together, and are sawed with difficulty. The end of the femur is received into a shallow depression in the tibia.

Histology.—Young bone. Epiphysial disks present in femur and tibia. The two bones are bound together by fibrous tissue, whose fibres run transversely. In this fibrous tissue are greater and smaller clefts, some of which contain blood and are lined by fibrin. The cartilage of the patella is closely applied to that of the tibia, and both are healthy, but that of the femur becomes more and more fibrous as it approaches the periosteum proximably, shading gradually off into it. At the proximal extremity of the cleft between the patella and the femur is a pouch lined with what appears to be synovial membrane. No other synovial membrane can be identified. In the distal end of the rift are fragments of cartilage, some of whose cells stain well. They can hardly be anything else but fragments removed at operation and left in the joint. This is very suggestive as to the possibility of the cartilage drawing its nutrition from the joint fluid.

Recapitulation.—Fibrous union, with clefts in the fibres. Free motion.

Dog 37 (544 days).—May 18, 1916: Resection of right knee. The very tips of the condyles and the tips of the tuberosities were removed with a scroll saw—hardly a centimetre altogether. The front of the condyles up to the top of the quadriceps pouch and the back of the condyles were also denuded. Patella left in. Wound sewed up with catgut in layers. Canada balsam. Gauze. Plaster of Paris spica.

May 22, 1916: The dog gnawed off the dressings, and ruined all the sutures, and the wound is open. The bone ends are fully exposed. The wound is therefore badly infected.

June 30, 1916: o. k. Wound nearly closed.

July 6, 1916: Two puppies last night.

July 7, 1916: Knee, in flexion and freely movable, has some lateral movement and is not used in walking. Ends of bones move on each other smoothly. The infected wound is still present on the anterior aspect of joint, but the rest of the wound has healed.

November 11, 1917: Killed in a fight. Considerable motion is present in joint. The tibia is at an angle of flexion of about 90°. Joint sawed sagittally. The bones appear to be simply tied together by fibrous tissue, and to have a joint cavity between them. Neither is much changed in shape. The patella is rather closely applied to the femur, but a joint cavity separates the two. The patella has not been caught at the level of section, and does not appear in the slides.

Histology.—The tibia and femur are separated by rather dense fibrous tissue, whose fibres run transversely. In this fibrous tissue are several larger and smaller irregular slits and spaces which contain detritus. No synovial membrane can be identified. A buttress of bone is present on each articulating surface, which is covered mostly by fibrous tissue, but in places is bare.

Recapitulation.—Fibrous union with clefts. Considerable motion, in spite of an infection.

SUMMARY

	Nature of operation	Days	Results
Dog 23.	Large amount removed.	975	Fibrous union—clefts.
Dog 24.	Mortise operation.	694	Bony union.
Dog 25.	Small amount.	14	No union.
Dog 26.	Large amount.	17	No union.
Dog 27.	Large mortise.	473	New joint, no cartilage.
Dog 28.	Small amount.	374	Fibrous union with clefts.
Dog 29.	Large amount.	1103	Fibrocartilaginous union with cleft.

	Nature of operation	Days	Results
Dog 30.	Small amount.	24	Fibrous union?
Dog 31.	Large amount.	922	Bony union with remains of fibrous cartilaginous union.
Dog 32.	Large mortise.	720	Bony union.
Dog 33.	Small amount.	930	Fibrous and fibrocartilaginous union.
Dog 34.	Small amount.	27	Fibrous and fibrocartilaginous union, with clefts.
Dog 35.	Mortise.	790	New joint lined with fibro-cartilage.
Dog 36.	Large amount.	150	Fibrous union with clefts.
Dog 37.	Small amount.	540	Fibrous union.

Fifteen operations, six with a small amount of bone removed, five with a large amount, four with mortise resection.

Four of these operations fall into a class by themselves. The time elapsing before the death of the dog was too short to do more than show the process of healing, not the result.

In the other eleven operations, three were with the removal of a small amount of bone, four with a large amount, and four with a mortise. These ran from 150 to 1103 days.

In two mortise operations (50 per cent.) and in one operation with removal of a large amount of bone (25 per cent.), bony union resulted, but in the last case, the bony union is only partial. Evidences of fibrous union remain in places.

In one case, a mortise operation, a new joint lined by fibrocartilage resulted. In the other cases the result varies—fibrous and fibrocartilaginous union, fibrous union with clefts, and a new joint lined by synovial membrane. In no case where a small amount of bone was removed, did bony union result, in spite of the elaborate care exercised to denude the whole articular surfaces.

Generally the conclusions reached in the first series of experiments stand.

At first sight very little of practical use can be distinguished in this series of experiments, but the more it is studied, especially in conjunction with the former series, the more significant it becomes, and the more light it sheds on the subject of non-union and of bony or complete ankylosis.

It will be recalled that in the ordinary healing of fractures a stage is reached when the bones themselves present a picture similar to that presented by most of the cases of our series in which union did not take place, namely, the fractured ends are not joined, but rather are separated by fibrous tissue which runs from the central marrow canals out to the periosteum. In fact, actual union of the bone ends themselves does not occur for a very long time. Union is brought about by the " wiped joint," the new bone produced in the periosteum, sometimes through the medium of cartilage, sometimes not. Where, from any cause, this wiped joint is not built up, non-union and a false joint are wont to result. My specimens of false joint after fracture show a striking analogy to the cases of this series which resulted in non-union. The same formation of fibrous tissue and fibrocartilage is present.

Skiagrams of old cases of non-union of fractures of the tibia and fibula often show a broadening out of the tibial fragments by the production of new bone, so as to make a larger bearing surface, but no indications of a real bony callus in the periosteum. The fibular fragments, not having any weight-bearing function, may show not the least indication of any new bone formation at all. They are as clean cut and unchanged as on the day of fracture.

In other words, as far as the bone ends themselves are concerned, if any motion takes place, Nature starts after fracture to build a joint between them, as she does after resections, but the new bone in the periosteum solders the whole thing up and holds it rigid. Not until long afterward, when the cortical bone is continuous, is the callus absorbed, never, in fact, while there is any need of it, or if the alignment of the fractured ends is not perfect.

In the region of the joints periosteum is not present. Hence a wiped joint cannot be constructed there. The ligament, unlike the periosteum, is composed of very dense fibrous tissue, and in its normal state is not a material out of which bone can be manufactured.[2]

It is known that bony union does not take place for a long time after ordinary resections. In some joints it almost never results. In the human knee it regularly results after a year or so. In the human knee conditions are unique. Two broad, flat, bony surfaces can be brought into close apposition, and can be held thus until they are tightly bound together by fibrous tissue. The immobility is increased by the adhesions in the quadriceps pouch, and a firm fibrous ankylosis results, which later is made bony. These requirements can rarely be met in resections of other joints, except perhaps by some such procedure as the Albee operation on the hip. It is extremely difficult, for instance, to secure bony union after excision of the elbow or ankle.

In the experimental resection of the dog's knee it is impossible to secure complete immobility invariably, even with the greatest care. Where little bone was removed, therefore, the bone ends, not greatly changed in their shape, were favorable for the retention of motion, and a new joint, of a greater or lesser degree of completeness, was built up in spite of our efforts.

In the mortise operations, the shape of the bone ends was changed radically, and the building of a new joint was made thereby much more difficult. The conditions in the human knee were approximated, and bony union resulted in two cases out of four.

In those cases where much bone was removed, it is probable that the line of resection passed through the bone at a level where it was covered by periosteum. Then, given efficient splinting, a wiped joint might be built up, and bony union would result. Vide dog 31.

To sum up, in the dog's knee-joint after resection, in spite of effi-

[2] Ely, "The Formation of Bone," ANNALS OF SURGERY, 1919, lxix, 225.

cient immobilization, when little bone is removed, bony union never results. With a mortise operation and great care bony union often can be secured. When much bone is removed, bony union occasionally can be secured.

In resections of the human knee, where bony union is desired, as, for instance, in tuberculosis, the bone ends should be sawn flat, and, if little bone be removed, they should be carefully approximated. Then, whether much or little bone has been removed, the limb should be carefully immobilized until a firm union, whether bony or fibrous, has been attained.

In arthroplasties it is known that the bone ends should be rounded off in imitation of their normal shape. Then, if they become covered with fibrous tissue or fibrocartilage, with clefts, we may expect motion, as we would in the dog, especially if the joint be not too carefully splinted afterward, and if active and passive motion be begun early.

These experiments throw light also on the subject of false joint after fracture. It has been said that the term "delayed union" should be applied to these cases rather than "non-union." This is not so. I have called attention to the fact that microscopic examination shows the formation of a new joint, with fibrocartilage, and sometimes with a synovial membrane. As far as our knowledge goes this is a permanent joint, the same as is any joint in the body, and the same as is the new joint in the dog's knee.

These false or new joints are known to occur most frequently at the junction of the lower with the middle third of the tibia, in the neck of the femur, and in the shaft of the humerus. In the last case the reasons assigned are the interposition of soft parts and the difficulty of holding the fractured ends in close apposition. These reasons seem perfectly logical, and often, if these factors can be overcome, union will result, provided a false joint has not been already built up. If it has, then naturally a bridge of bone must be established and a communication of the two marrow canals so that new bone can be built along the bridge.

In the case of the tibia, two explanations are offered. The first is the vague one of deficient blood supply. The tibia has a sufficient blood supply. Its marrow is well supplied with blood-vessels and is quite active. The blood supply of the calcaneus and talus and of the other bones of the foot is sufficient to effect union in them after fracture. Even in a child, whose blood supply is excellent, a spiral fracture of the tibia will take a long time to heal, and will require efficient immobilization.

The second explanation is that a fold of periosteum is caught between the fragments. It is doubtful if this happens any more frequently in the tibia than in other bones, and it is doubtful whether a fold of the periosteum would check union, even if it were caught. The periosteum has a decided bone forming function.

Observing the frequent absence of bone formation in the periosteum after fracture of the tibia, *the essential factor in union after most fractures,* a promising line of investigation would be a study of the structure

of the periosteum in this region. In this, perhaps, lies the key to the riddle. Again, in spiral fractures it is hard to keep the fragments in close apposition.

Whitman, I believe, has partially solved the problem of non-union after fracture of the femoral neck, and I think my dogs have cleared up what remained. He maintains that at the bottom of the difficulty lie faulty apposition and immobilization. Given efficient splinting, union will result. Probably it will, *in spite of the absence of the periosteum and the wiped joint.* Manifestly deficient circulation has little to do with the problem. If the femoral head had no circulation at all (as it generally has through the ligamentum teres, and possibly from the capsule), nevertheless, if it be held closely against the distal fragment, it should unite to it, as a dead graft will unite to live bones when it bridges a gap between them. All grafts probably die, and are efficient only as new bone is built upon the old by new blood-vessels pushing into them from the receiving bones.[8] So new bone should be built up on the dead trabeculæ of a head without circulation, by the action of blood-vessels pushing in from the neck.

In old cases of fracture of the femoral neck the great difficulty in bone grafting operations with a peg of new bone is that we expect too much. We expect that through this slender peg blood-vessels will push their way, and regenerate and build up the head of the bone, which has atrophied and lost its normal structure, and which has already become joined to the neck by dense fibrous tissue. The peg often unites, and we think union has taken place, but it is a very slender union, and breaks in the course of a few months, as the result of a slight strain or twist. It would be interesting to immobilize these cases for a couple of years, and see if in these circumstances the union through the peg could be made a firm one, and sufficient new bone could be built up on the old trabeculæ of the atrophied head to stand the necessary strain.

CONCLUSION

My thesis in brief is this: After a fracture or a resection the whole tendency of the resulting process between the bones themselves, unless they are held firmly together without motion, is the separation of the bone ends by fibrous tissue and fibrocartilage, with a new joint, before the bones can unite. In order for bony union to occur the bone ends must be held in contact absolutely immobile. In the ordinary fracture Nature provides the immobility by a bony callus outside the cortex, in the periosteum. In those situations where the bony callus is not laid down, a false joint usually results unless complete immobilization is maintained until actual union of the bone ends occurs.

In resections the external bone callus does not form. Hence, unless the mechanical requirements of complete rest can be answered, resections of joints are not followed by bony ankylosis.

[8] Ely, "An Experimental Study of Buried Bone." To appear in an early issue of this journal.

FRACTURES OF THE NECK OF THE FEMUR*

ANALYSIS OF 116 CASES

By Willis C. Campbell, M.D.
of Memphis, Tenn.

The old adage "Many Remedies No Cures" is truly applicable to the average treatment of central fractures of the neck of the femur, though much has been written by Whitman, and others, showing undoubted evidence of excellent results in a large proportion regardless of the age; however, his method does not seem to be universally understood, and the number of ununited fractures of the neck of the femur is as great as ever.

It is also true that due consideration may not be given to type, anatomical location and mechanism of reduction in fractures on this region which differ widely as to prognosis:

(1) Fractures of the base of neck, intertrochanteric and below trochanter, unite readily.

(2) Fractures of the neck with distal fragment within acetabulum may give good functional result without bony union—a fact well worthy of note.

(3) Impacted fractures occur usually at junction of neck with head or with trochanter—may unite by simple rest in bed, or any form of support that prevents loosening of impaction. I do not regard a majority of fractures of this region impacted, as do some authorities, but only those cases in which a distinct telescoping can be demonstrated. If the relation of the fragments is so unstable that the slightest jar will dislodge, no appreciable impaction exists.

(4) Fractures of the neck proper or "central" is the only seat where non-union occurs with a greater degree of frequency than other fractures; in fact, to such an extent that until recent years no bony union was considered possible; consequently, this fracture alone is worthy of discussion, as fractures at other points in the vicinity uniting as any normal bone do not present a real surgical problem. Hence, unless a thorough knowledge of the subject exists, reports may be misleading.

As soon as possible after fracture a skiagram is made which must present perfect definition, or impaction may be overlooked. Especial care is taken not to move limb, manipulations avoided. Under ether or scopolomin-morphine the patient is placed in the desired position on an orthopædic table, and a second skiagram made when cast is applied if adjustments of fragments are satisfactory. At the end of eight weeks cast is removed and a third skiagram showed in all excellent reduction of fragments. When possible repeated skiagrams are made during ensuing two years.

The technic of various measures in common use is well understood,

*Read before the Orthopædic Section of the American Medical Association, June, 1919.

with possibly the exception of the Whitman method which consists in forcible abduction to the limit, extension and moderate internal rotation. In this position a cast is applied from nipple line to toes (for detailed information one is referred to Whitman's "Orthopædic Surgery" and numerous monographs on the subject). In my series I only employed the Whitman position in central fractures. I did use abduction and internal rotation in trochanteric and other types, but only commensurate with the exact location of the fracture. In three abduction flexion and internal rotation was found advisable to facilitate early sitting posture.

As all of my cases were in plaster casts from nipple line to toes, the after-treatment was the same regardless of the seat of fracture: (1) The position is changed every two hours for the first week, thereafter every three hours. (2) All urine is saved for twenty-four hours. Complete analysis is made daily with special attention to quantity. (3) Very old or feeble cases are placed in special chair, at intervals daily, being encouraged to eat three meals, if possible, in this position. (4) Walking on crutches is allowed at the end of three months. No weight bearing for at least six months, otherwise there is danger of bending or even separation.

The purpose of bringing this subject before you at the present time is a statistical discussion of the relative value of various methods employed, as shown in a comparative study of 116 cases, 70 of which were fresh fractures directly under the personal care of the writer, and observed sufficiently early to elect any method. The remaining 46 were largely ununited fractures months or years after injury. The age of these cases ranged from 9 to 88, though practically all were in the aged, a majority being above 60.

Of the 70 fresh fractures, 15 were trochanteric and united readily; 7 were impacted with the same excellent result; 7 below trochanter gave 100 per cent. firm bony union; 5 died (3 uræmia, 1 pneumonia, 1 anæsthesia); 7 are too recent for consideration; 29 were central and were treated by the Whitman abduction method; of these 24 gave excellent functional results, by which is meant that the patient was able to walk without support, pain or discomfort, and with every evidence of bony union; 4 failed; 1 result unknown. A slight limp persisted in a majority, though quite a number walked perfectly. An X-ray study was made when possible in every case for one year. In 2 a gradual coxa vara developed, though union appeared firm. In one there was a gradual separation. In others that we were able to follow, there was no change in the angle.

From the limited experience of the writer there is no method by which we can determine bony union except time, with the development of perfect function and stability. Forty-four ununited fractures of the neck of the femur were observed, all of which were central; not one trochanteric or below trochanter was found. No facts regarding impaction could be ascertained. From the history 14 were treated by Buck's extension; 9 plaster casts; 4 Hodgens splint; 9 sandbags; 2 osteopathy; 1 ambulatory; 5 no diagnosis—no treatment. Of these 44, 24 were operated; in two, edges

freshened—1 successful—1 failure. In 7 the wire nail was driven through trochanter neck and head—2 successful—4 failed—1 improved. In 15 the tibial graft was employed—in two of greater risk the anterior incision was omitted and the graft used with practically the same technic as wire nail. This can be done with rapidity and certainty by X-ray connections in operating room, allowing skiagrams during the process of the operation. Of these 15, 11 were successful—2 failed—1 improved—1 too early to draw conclusions. Grafts were not used when marked atrophy of head was apparent.

In old ununited fractures absorption of the head and neck is not so rapid as we are led to believe by the average skiagram carelessly taken in external rotation, or because internal rotation is painful. Repeatedly I have been pleased to find a well developed neck after two or more years, when the hip was abducted and rotated inward. On the other hand, I have seen marked rapid absorption of the head. In one case scarcely a trace could be found in the acetabulum at the end of two years, though walking was possible without crutch or support, as the neck was within the hip socket.

Two apparently non-impacted central fractures of the femoral neck healed by firm bony union without any form of treatment other than rest in bed. In these cases, which were seen about one year after accident, there was fixed external rotation, shortening 1¼ inches, but function was excellent, no pain, and the joint quite stable.

From the number of non-union in central fractures in this series, it is not surprising that the laity and profession regard the condition as almost hopeless. When we compare 29 central fractures, 24 of which were excellent results, with 44 failures by methods in common use, the efficiency of the former is apparent; though circumstances are not analogous as only failures present themselves for treatment; however, the occurrence of ununited central fractures is of sufficient frequency for one to draw conclusions.

The mortality is less by proper management in a plaster cast than by other methods. In fact, if the condition of the patient warrants any form of treatment, an efficient plaster dressing in the desired position is as safe as any other method.

In this series, 70 acute fractures and 24 operated for non-union, a total of 94, were placed in casts extending from nipple line to toes, and in some instances the opposite limb to the knee. Only four deaths occurred and those in acute fractures. Not one died following operation, but these were selected cases. The risk is almost *nil* if one considers the pain, disability and invalidism of non-union in this region.

It is not my intention to infer that there are no other methods worthy of consideration. The Jones splint may be effective; so may Ruth-Maxwell traction or any mechanism by which anatomical reduction is secured.

The writer merely desires to emphasize by case reports one very efficient, probably the most efficient, method, as clearly shown when compared with failures by methods in common use.

FRACTURE OF THE FEMUR: THE APPLICATION OF WAR LESSONS TO CIVIL PRACTICE*

By Carleton R. Metcalf, M.D.
of Concord, N. H.
Lieutenant Colonel, M.C., U.S.A., in charge of Base Hospital 88, Savenay, France

This is a period of renaissance in the treatment of fractures of the femur. I believe that the familiar Buck's extension apparatus is to become obsolete; that, more and more we are going to procure traction by the use of calipers, and that the Thomas splint, so generally employed in the recent war, is to become for this lesion of the femur the keystone of support, fixation, extension and counter-extension; that the Thomas splint, which abroad has long blushed unseen, is destined to come into general use in the United States, is destined to be adopted here for civil surgery. I believe that with a Thomas splint, properly applied, one may, with few exceptions, obtain a good functional and anatomic result in every femur fracture.

In discussing the use of the Thomas splint I have visualized my patient lying flat on his back in bed. The term "forward," therefore, means "in the direction of the ceiling," and a "vertical" pull is a pull ceilingward. A "backward" displacement is a displacement in the direction of the floor. The phrase "in front" denotes anterior; the phrase "behind" denotes posterior. "Upper" or "proximal" signifies "towards the patient's head;" "lower" or "distal" towards his feet. An "upward" pull is a horizontal pull towards the head of the bed, a "downward" pull the converse. "Outer" and "outward" suggest a position away from the axis of the body, "inner" and "inward" a position towards the axis of the body.

I. TYPES OF FRACTURE

Fractures of the femur may be arbitrarily divided into four groups: (1) Intracapsular; (2) upper third; (3) middle third; (4) lower third. In these several groups we find specific deformities which must be counteracted.

1. Intracapsular.—In war clinics one rarely sees impacted fracture of the hip. We have dealt, on the contrary, with loose fractures in healthy young adults.

Deformity.—Upward dislocation of the femur. In neglected lesions there has been, in addition, persistent adduction of the thigh. To *counteract:* Thomas splint. Traction, with thigh in abduction to 35 degrees and in flexion to 30 degrees. In this position the foot naturally rotates outward slightly and should be so held. After overriding has been corrected,

* Authority to publish granted by the Surgeon General, U. S. A.

immobilize in a plaster spica. This is analogous to Whitman's treatment for impacted fracture of the hip.

2. Upper Third. a. *Fracture Just Above the Small Trochanter.*

Deformity.—(1) Upper fragment abducted. (Glutei pulling on great trochanter.) (2) Upper fragment not flexed. (Insertion of ilio-psoas is below site of fracture.) (3) Lower fragment drawn upward, inward and slightly forward. (Composite effect of extensors, adductors and flexors of thigh.)

Fig. 1.—Fracture just below small trochanter. Upper fragment abducted, flexed and rotated outward. Lower fragment drawn slightly upward and inward. A common deformity.

Fig. 2.—Fracture distal to that shown in Fig. 1. Same deformity.

To *counteract:* Straight traction in abduction.

b. *Fracture Just Below the Small Trochanter.*—Common type of fracture (Figs. 1 and 2).

Deformity.—(1) Upper fragment abducted. (Glutei pulling on great trochanter.) (2) Upper fragment flexed. (Ilio-psoas.) (3) Upper fragment rotated outward. (External rotator group—obturators, pyriformis, gemelli and quadratus—more than counteract anterior portions of gluteus medius and minimus, tensor fasciæ femoris and ilio-femoral ligament.) (4) Lower fragment drawn upward and inward. (Composite effect of extensors, adductors and flexors of thigh.)

To *counteract:* Thomas splint. Traction, with thigh in flexion to 30

degrees and in abduction (about 35 degrees) until the lower fragment has been brought into alignment with the upper. Flex knee 25 degrees. Support the lower fragment posteriorly to prevent subluxation. Utilize "screw pads" (Fig. 12). They are attached to the longitudinal rods of the Thomas splint. If outward rotation is not overcome by the vertical pressure of the ring of the Thomas splint, it can be compensated by rotating, to a like degree, the lower fragment.

c. *Oblique Fracture, Downward and Inward, Below the Small Trochanter. Deformity.*—Upper fragment flexed but adducted (in distinction to the abduction of the two preceding types) by the pull of the adductor muscles inserted near the small trochanter. To *counteract:*

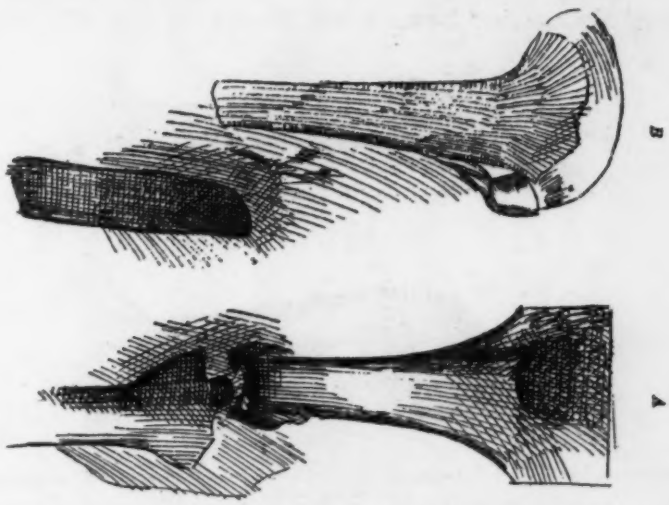


FIG. 3.—Fracture of lower third of femur. Lower fragment tilted backward, slightly adducted, slightly rotated outward. *A*, antero-posterior view. *B*, lateral view.

Thomas splint. Traction, with thigh flexed and adducted to bring the lower fragment into alignment with the upper fragment.

3. MIDDLE THIRD. *Deformity.*—(1) Lower fragment drawn upward. (2) Lower fragment tilted slightly backwards. (Gastrocnemius.) To *counteract:* Thomas splint. Traction. Correct subluxation by posterior support. Utilize "screw pads" for insistent pressure on either side of the thigh.

4. LOWER THIRD (Figs. 3 and 4). *Deformity.*—(1) Lower fragment tilted backward. (Gastrocnemius.) (2) Lower fragment slightly adducted and slightly rotated outward. (Adductor magnus.)

To *counteract:* Traction, with the knee flexed from 35 to 90 degrees. It is necessary to have firm support behind the lower fragment, especially if traction is made by some means other than calipers.

The best support is a large, firm pad, pressing on the posterior surface of the thigh in the area of the lower fragment. Such support tends to

push the lower fragment forward when traction is made on the flexed leg. Adduction and outward rotation can be best counteracted by calipers, but these two deformities are usually slight in degree.

2. COMMON DEFORMITIES

In fact, the deformities which one must guard against particularly are four in number. These occur time and again in fracture of the femur. The necessity for avoiding them cannot be too sharply emphasized. They are:

1. Excessive shortening, because of inadequate traction or poor position or both. A good result entails shortening of less than one inch.

2. Subluxation of the shaft, because of inadequate posterior support. The normal shaft arches forward, but this arch is lost in fractures of the

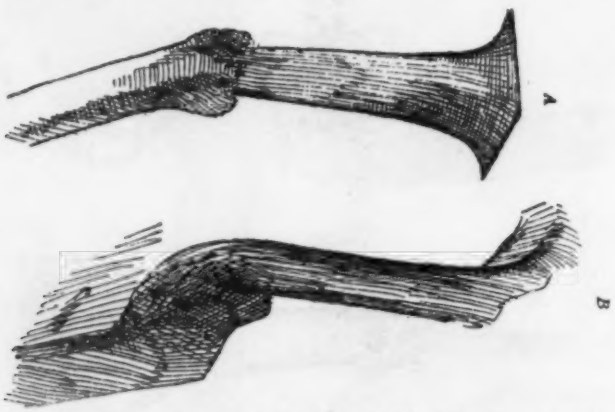


FIG. 4.—Fracture of lower third of femur, united in characteristic deformity. *A*, antero-posterior view. *B*, lateral view.

middle and lower thirds. Here, unusual vigilance is the price of normal alignment.

3. Rotation of the lower fragment on the upper, with the result that a patient ultimately toes out or toes in. If one remembers that the foot should be straight up and down when the lower extremity is in the line of the body, this rotation can be avoided. As the lower extremity is abducted, the foot naturally turns outward. Observe the position of the foot on the uninjured extremity and be guided thereby in determining the position in which the foot should be held on the injured side. The patient's foot may readily be suspended from or affixed to the foot-piece of the splint in such a way that the proper position is maintained.

4. Abduction of the upper fragment (Figs. 1 and 2). In fractures above the middle of the shaft, do not forget to abduct the leg—do not forget to bring the lower fragment outward until it is in alignment with the upper fragment. It is commonly stated that real abduction is secured only if the pelvis and opposing thigh are fixed. In the case of old, ununited fractures in malposition, this statement is true. If the

lesion be recent, the statement is not true. Given a fresh fracture of the femur, fixed with a Thomas splint, one may maintain real abduction to 35 degrees without immobilizing the pelvis or the intact thigh.

3. FUNDAMENTAL POINTS IN THE USE OF THE THOMAS SPLINT

The Thomas splint serves as a foundation stone in several methods of treating fracture of the femur. Whichever method one employs, a few fundamental facts must be observed. For example:

1. The size of the ring of the splint is not a vital factor, so long as it be large enough. A snugly fitting ring is preferable but not essential.

FIG. 5.—Fracture of lower third of femur. Occasionally in an oblique fracture the lower fragment is caught anteriorly.

2. The posterior portion of the ring should, however, impinge against the tuber ischii.

3. This intimate, unchanging contact can be procured only when there is a vertical pull on the ring. It is necessary, then, to lift the ring ceilingward with sufficient force to prevent it from slipping into the groin and riding above the tuber ischii.

4. The distal end of the splint must be elevated.

5. To facilitate (*a*) the vertical lift on the ring and to provide (*b*) a means of maintaining elevation of the distal end of the splint, it is important to erect an overhead frame of wood or of metal. The original frame for these purposes was called the Balkan frame, and I shall use this term loosely to describe an overhead frame. Herewith are illustrations of four frames. Frame 1, of metal, is light and serviceable (Fig. 6). Frame 2, of metal, is that produced by Pearson (Figs. 10 and 11). Frame 3, of wood,

answers our purposes but is heavy; it cannot readily be used for anything but a thigh or leg (Fig. 7). Frame 4, of wood, is that devised by Blake and adopted for the American Expeditionary Forces. It is light, simple and adequate (Fig. 9).

6. The Thomas splint should be bent in slight flexion at the knee—ordinarily to about 25 degrees from a straight angle. This amount of flexion is to be increased in fractures of the lower third of the femur.

7. A foot-piece may be erected to hold the foot at right angles. When a foot-piece is used, it is an integral part of the splint. The foot may

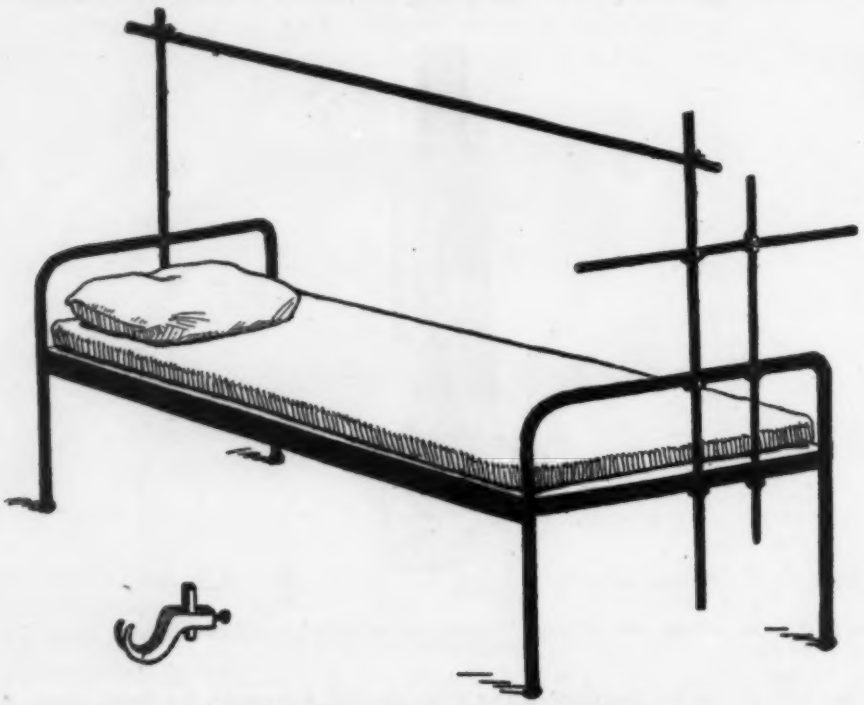


FIG. 6.—Frame 1. Gas-pipe clamped to bed frame.

simply rest against this flat support; it is preferable to glue a piece of cloth to the sole of the foot and to attach the free end of the cloth strip to the horizontal rod of the foot-piece. After its rotation has been adjusted, the foot is allowed to swing free in a right-angled position.

8. Posterior support is had by doubled strips of flannel bandage, running behind the limb, from one side-rod to the other. By "limb" I mean the lower extremity, from groin to foot. These flannel strips extend from the ring of the splint proximally to the Achilles tendon distally and must be closely approximated, so that there is a continuous flannel trough. In this respect the illustration (Fig. 11) is incorrect. The two free edges of each strip wind round the outer side-rod and are secured by safety-pins, not by metal clips.

9. Traction is procured by weight and pulley. The initial weight should be the maximum. Exert the greatest pull at the start. Usually less than 20 pounds suffices. Do not commit the mistake of beginning traction with five pounds and gradually increasing it; rather start with the maximum weight and gradually scale it down. Caliper traction demands less weight than other forms of traction.

10. If pull and proper position do not suffice to secure alignment,

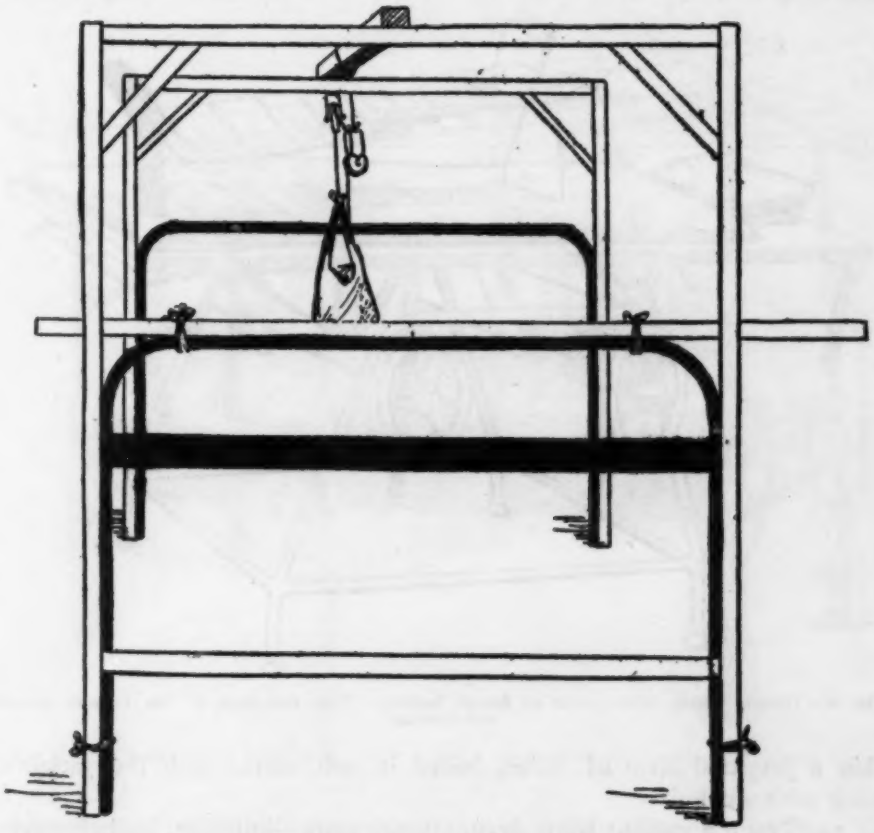


FIG. 7.—Frame 3. Of heavy wood. Not suitable for arm lesions.

employ "screw pads." When these pads are employed, two are needed—one pressing the upper fragment into position, the second exerting counter-pressure on the lower fragment. Thus the pads are on opposite sides of the thigh. In obdurate lesions these pads are very effective. They have proved so harmless that one is constrained to disregard utterly a former axiom, that a fractured bone should be pulled rather than pushed, laterally.

11. Leave the knee free and uncovered. Massage of the joint minimizes the probability of final knee-joint disability. With Pearson's appa-

ratus not only can the knee, leg and foot be massaged, but the knee, ankle and toes can be moved. Begin massage and passive motion early.

12. Examine the splint daily. Adjust the flannel slings, check traction and position. Measure the length twice a week. But do not disturb the fracture needlessly. Check alignment and callus formation with X-ray pictures; a bedside machine is of great help.

13. Watch the perineum. Soap the ring before applying the splint, and soap it daily thereafter. Pearson passes between the ring and the

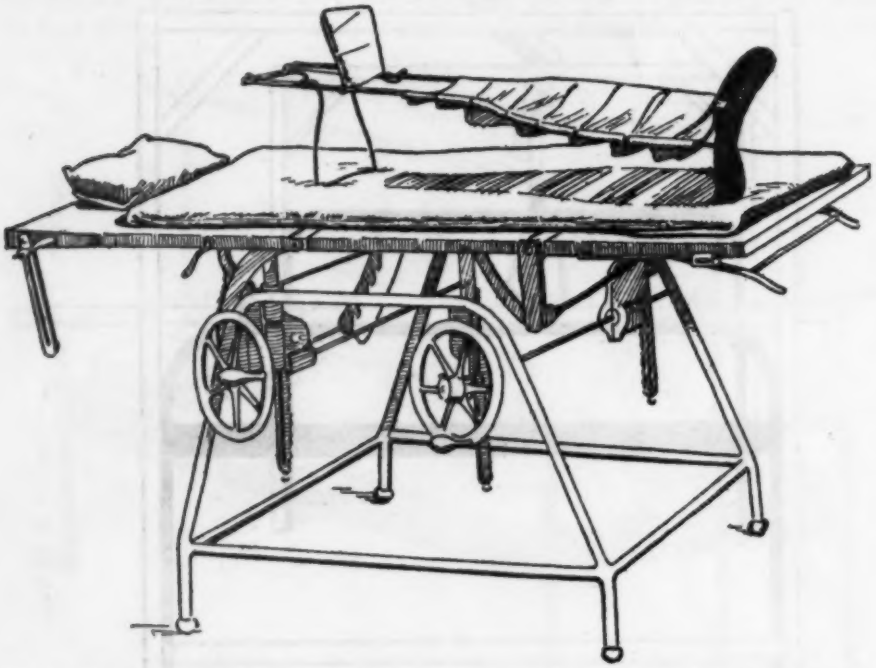


FIG. 8.—Thomas splint. Note gutter of flannel bandage. Note foot-piece, in this instance wound with bandage.

skin a prepared strip of calico, boiled in soft soap. Rub the patient's back with alcohol.

14. Teach a patient some occupational work—knitting, basket-weaving, painting, or the like—to busy him during his protracted confinement.

4. METHODS OF FIXATION AND TRACTION

With these elemental points in mind, we may consider the details of two methods of fixation and traction: (*a*) Pearson method; (*b*) modification of the Pearson method, used at Savenay, which, out of hand, may be called the Savenay method.

If a freshly fractured femur exhibits no deformity or if one has the means of reducing completely such deformity as exists—a Hawley table, for example—it may be quite justifiable, in non-compound lesions, to resort initially to a plaster spica, checking one's result with the X-ray.

An impacted fracture which is not to be broken up offers the same possibility. Under any other circumstances, one courts shortening if he places the limb in plaster immediately after injury. Under any other circumstances traction is essential in the early days of treatment. Both methods just enumerated are based on traction, combined with suspension. In them the end of the splint is attached, at the foot of the bed, to the cross-bar of the Balkan frame. In the latter, indeed, the end of the splint projects a few inches beyond the cross-bar and is blocked in this position.

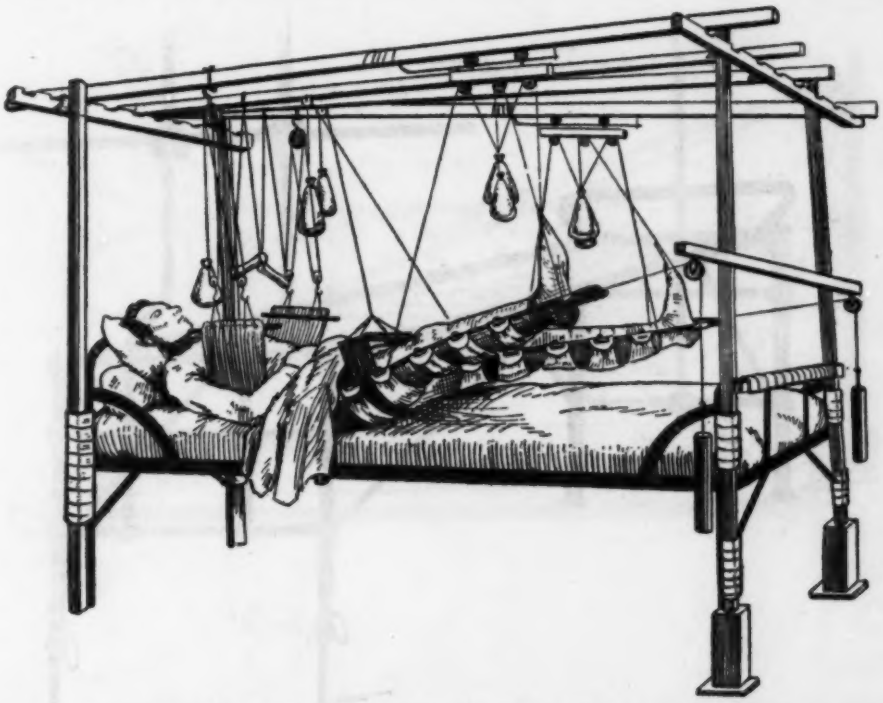


FIG. 9.—To illustrate the Blake frame. The method of procuring fixation, traction and suspension varies slightly from the methods to be described in this paper. (After Blake.)

The pulley is affixed to the proximal side of this cross-bar, between the two longitudinal rods of the Thomas splint.

Familiarity with any method breeds good results. For the surgeon who has tried none, however, there is a choice. I prefer the Pearson technic above all others. I follow the Savenay technic when I am unable to obtain the special apparatus designed by Pearson.

a. *Pearson Method.*—Pearson always uses calipers and he has devised several pieces of special apparatus. My description and illustrations of Pearson's technic are synopsised in part, with permission, from that surgeon's published papers; I would call attention to a book that Pearson is about to publish, which gives intimate details.

Pearson has worked out a special bed which makes more facile the

care of a femur patient. The upper legs are fitted with castors, the lower legs telescopic, so that the foot of the bed may be tilted at will. At the head end is a derrick by which a patient can raise himself; it cannot swing because its lower end is hexagonal and fits into a hexagonal cup; it can, therefore, be put in any one of six different positions. At the foot of the bed near each corner is a similar hexagonal socket into which a spare derrick can be inserted to suspend a leg or into which a steel tubular cranked extension post may be fitted. The mattress is divided into sec-

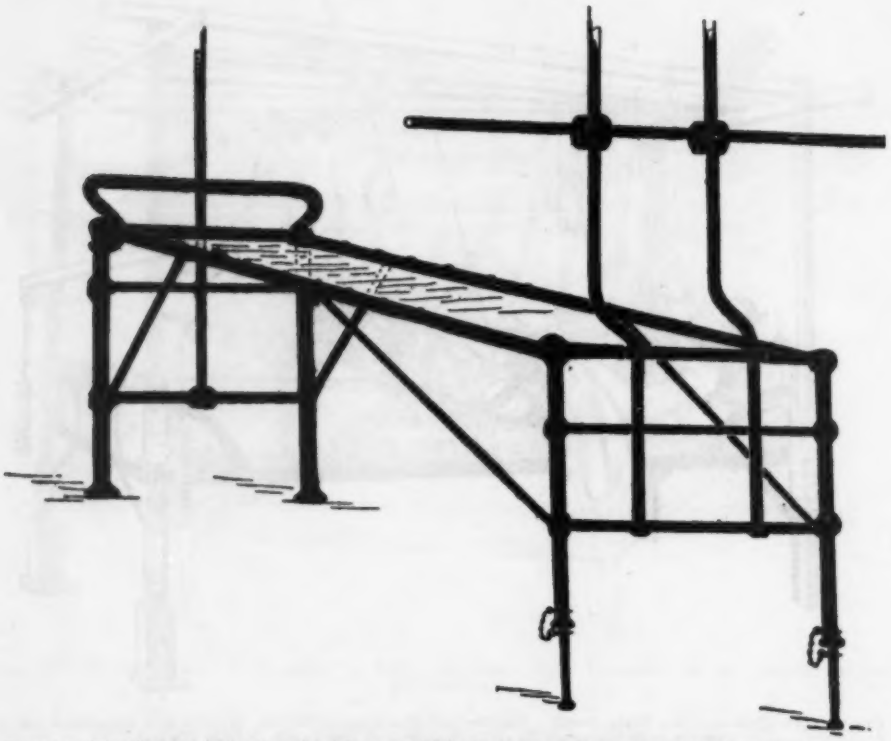


FIG. 10.—The Pearson bed. See also Fig. 11, which shows extension post, sectional mattress and sectional canvas support. (After Pearson.)

tions, one of which may be removed to facilitate dressings or to simplify the use of a bed-pan. In the latter event the bed-pan is supported by a section of canvas, stretching from side to side (Fig. 11).

A knee-flexion piece is grafted onto the Thomas splint with the hinge at the level of the knee-joint. A narrow foot-piece in the form of an arch is affixed to the knee-flexion piece. From this arch the foot is suspended by a strip of gauze glued to the sole. Movements of the leg, at first through an arc of only a few degrees, are carried out daily from the beginning.

Pearson's caliper is a modification of Besley's and is non-penetrating. It has an adjustable screw bar between the handle ends. When the caliper points are on the surface of the bone, this screw is so adjusted that " day-

light is just visible between its ends." In most cases this separation lasts many weeks; penetration, in other words, is practically *nil*.

Extension and fixation are carried out in the following way. Attach the knee-flexion piece, transfer the leg to it, suspend the foot, affix the extension post to the foot of the bed and bind the lower end of the Thomas splint (not the knee-flexion piece) to the extension post at a proper height. Attach a pulley. Procure cord, five-pound weights and the metal hexagon shown in Fig. 13.

Lift the thigh well forward in the Thomas splint by tightening the

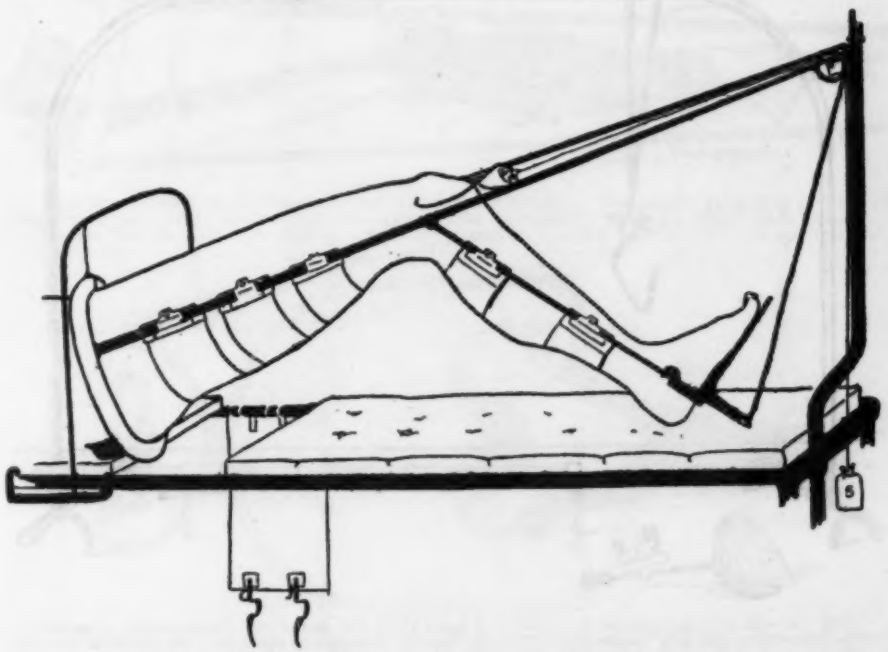


FIG. 11.—Pearson apparatus. Note (1) knee-flexion piece, (2) foot-piece, (3) caliper extension, (4) metal arch to which is attached the cord that exerts vertical pull on the ring of the Thomas splint. (After Pearson.)

supporting bands. Prepare the skin around the knee, surround the joint with sterile towels and give a whiff of gas. Draw up and slightly forward the skin over the inner and outer condyles. Cut down to the bone on either side of the femur and, without relaxing the skin, insert the sterilized caliper points. The points must impinge on bone; but they should not enter the bone. Nor should there be any intervening soft tissue between caliper points and the bone. The exact point of insertion is important for one must avoid the knee-joint. At the inner side, make the cut a finger's breadth on the proximal side of the adductor tubercle. At the outer side make the cut proximal to the most prominent point of the outer condyle and anterior to the ilio-tibial band. This brings the cut 1½ inches from the outer border of the patella above its middle. The

common mistake in applying calipers is to place them too far forward, in front of the greatest diameter of the bone.

Hold the calipers firmly while an assistant ties the handle to the hexagon and the hexagon, in turn, to a weight and pulley system. For a fresh case a five-pound weight is ample; in old cases with shortening, 15 pounds may be necessary at first. In the rare instances where added weight causes pain, elevate the foot of the bed a few inches. The patient slides away from the ring of the splint; counter-extension is afforded by

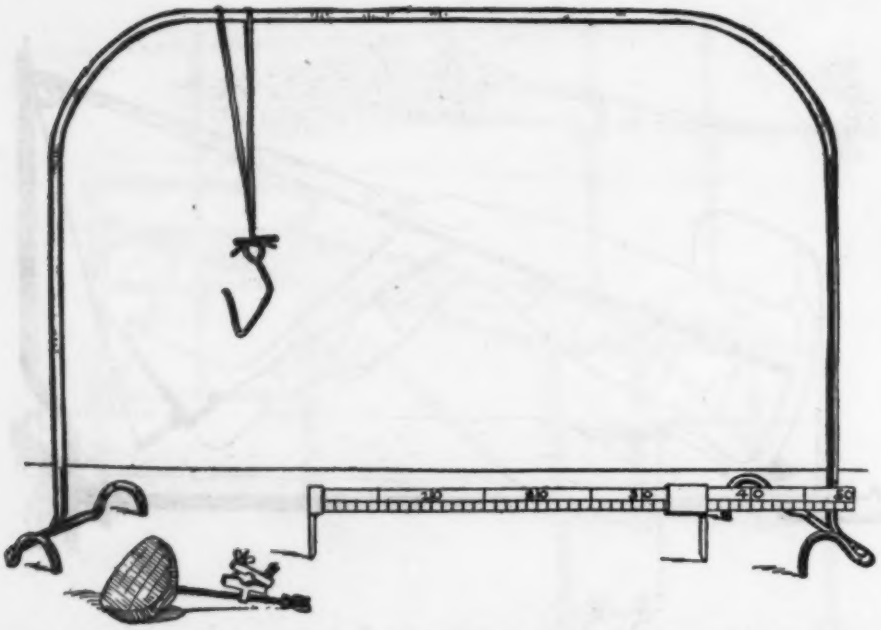


FIG. 12.—An enlarged view of the metal arch from which the ring of the Thomas splint is supported. In the lower left corner is a "screw-pad." Two of these are clamped on the splint, one on either side-rod. At the junction of pad and thumb-screw is a ball-and-socket joint. In the lower right-hand corner is a sliding rule which supersedes the customary tape measure. (After Pearson.)

the patient's body and no longer by the ring pressing on the tuber ischii (Figs. 11–16).

When union has begun adopt the second position. Swing the lower end of the Thomas splint high. Employ for this purpose a cord, weight and pulley—the pulley being fixed to a spare derrick or other overhead suspension at the foot of the bed. This allows greater freedom of movement. The weight extension in the line of the thigh is superseded by an elastic or spring extension. A spring balance serves admirably, inserted between the hexagon and the end of the Thomas splint. Pressure of the ring on the tuber ischii must be maintained.

When union is fairly firm dispense with the calipers. *Do not take the limb out of the splint and begin flexion of the knee over a pillow.* Instead, tilt the rigid Thomas splint upward into an "anti-aircraft" position.

This manœuvre gives a greater range of motion to the knee-flexion piece, whereby knee flexion to 90 degrees may be attained in from two to three weeks. Tie a cord to the knee-flexion piece, and bring it up vertically through a pulley to the patient's hand, so that he may move the knee himself. Continue, during this period, to support the thigh in its flannel slings, using " screw pads," if necessary, for lateral control.

The two great advantages of this method are that it is mechanically efficient and that it permits freedom of movement in the leg and in the joints below the site of fracture. The caliper points do not cause sepsis

FIG. 13.—Front view of caliper extension. Note metal hexagon. This permits the foot to be elevated when the leg is moved vertically. With this apparatus the leg strikes on the caliper before the full extension is obtained, but the ability to extend completely is quickly regained after the calipers are removed. (After Pearson.)

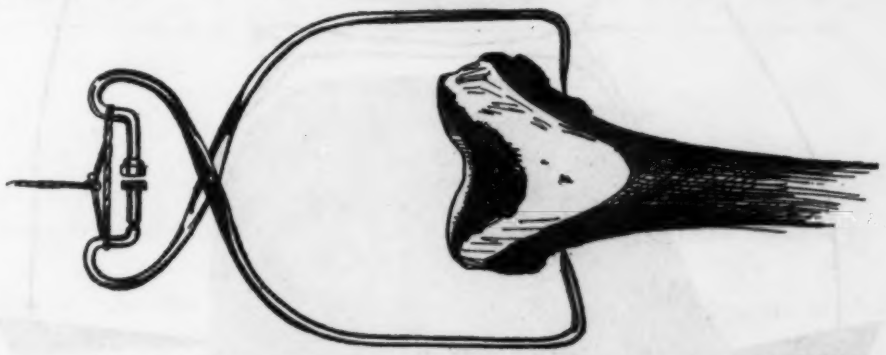


FIG. 14.—Antero-posterior view of caliper points. Note relation of points to joint capsule and adjustment of screw-bar between handle ends. (After Pearson.)

or necrosis. Invasion of the knee-joint is evidence of carelessness. The only disadvantage is pain about the caliper points, lasting for a day or two after they are inserted. This pain is ordinarily due to one of three errors:

1. A small skin incision which inhibits the escape of sterile pus that may form about the caliper points. The incision should be about half an inch.

2. Incision not reaching to the bone. The caliper points slip and cause tension on the skin.

3. Caliper points incorrectly placed—either too far forward or too close to the top of the adductor tubercle.

Pearson gives the following directions for the dressing: " Dry gauze soaked in 1:500 Flavine in spirit solution is applied around the points and changed every second day. It is not uncommon to have a slight discharge around the points. It is sterile. Introduce a little of the solu-

tion through the needle of a hypodermic syringe along the side of the caliper points." We have used iodine for the dressing or have protected the junction of skin and caliper with collodion.

b. *Savenay Method.*—At Savenay there has been difficulty in obtaining Pearson's calipers and his other special paraphernalia. My predecessors, therefore, evolved a mongrel method which embodies some of Pearson's ideas. In lesions that are not too old we have ordinarily obtained, by it, good alignment and less than an inch of shortening.

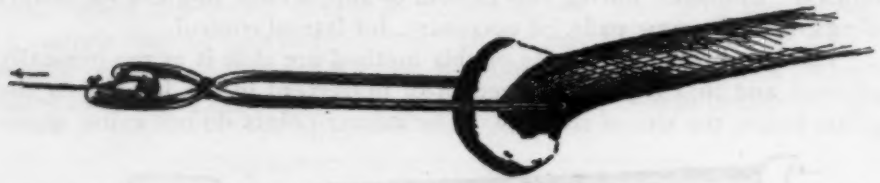


FIG. 15.—Lateral view of caliper points. Note relation of points to joint capsule. (After Pearson.)

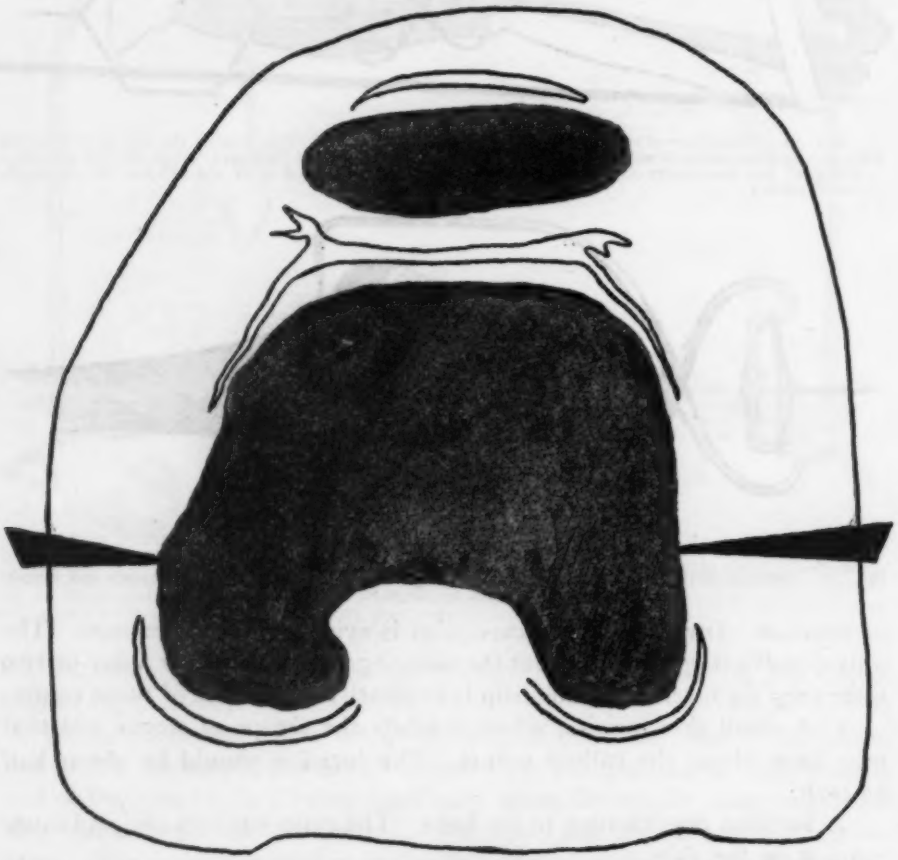


FIG. 16.—Cross-section view of caliper points. Note relation of points to joint capsule. (After Pearson.)

The Savenay method observes the fourteen elementary points that have been propounded. It diverges from Pearson in the following:

1. We have omitted the knee-flexion piece. The Thomas splint has been bent into flexion at the knee about 25 degrees from a straight angle and the limb has been allowed to rest in this position.

2. Traction has been secured with moleskin—two three-inch strips extending downward from the site of fracture and terminating in the customary webbing bands. The moleskin strips are made more secure by bandaging the leg. Just beyond the sole of the foot the webbing bands are held apart by a wooden spreader which prevents them from chafing on the malleoli. Their free distal ends are tied to the cord which forms an integral part of the weight and pulley system. This form of traction is safe and easy, but has the disadvantages that the knee is kept ex-

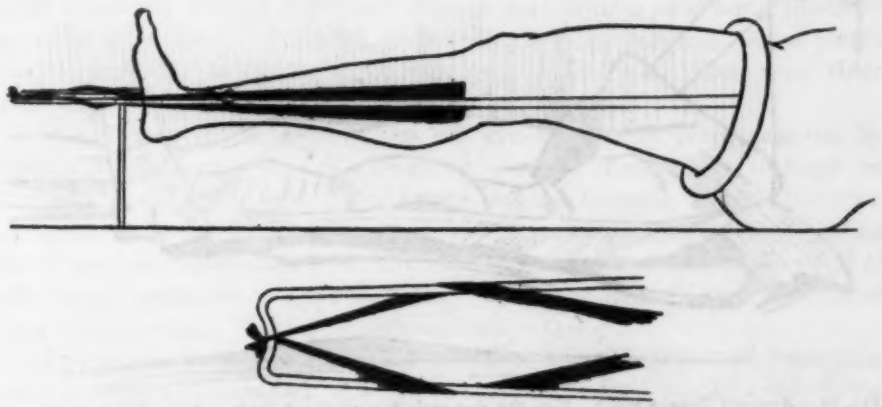


FIG. 17.—Moleskin traction. Usually the moleskin strip is wider and extends further upward on the thigh. (After Pearson.)

tended, that the force is applied mainly through the ligaments of the knee-joint and that the skin may become irritated. Moleskin is less irritating, however, than glue, and for this reason we have avoided glue; nor have we employed the Codavilla pin or the stirrup of Finochietto.

Blake has this to say of the methods of securing traction: "The first and most common method is to attach the tractive force to the skin, either by applying bands of Canton flannel or of gauze by means of Sinclair's or Heussner's glue, or, better, by using the well-known moleskin or diachylon plaster. . . . Ordinary adhesive plaster is valueless on account of its slipping. When moleskin plaster is used the end of each band is cut into three strips—a wide central piece which is applied straight, and two lateral narrow bands which are applied in opposing spirals avoiding the front and back of the knee. The bands are adjusted from just above the ankle to above the knee if possible. . . . The bands cannot be applied solely to the thigh above the knee because the tractive force is then chiefly transmitted by the skin and fascia to the pelvis."

Blake gives the following formula and directions for the manufacture and application of Sinclair's glue:

Glue	50 parts
Water	50 parts
Glycerine	2 parts
Calcium chloride	1 part
Thymol	1 part

Paint the warm glue directly on the skin, painting the hairs upward. Clean the skin initially with soap and water, followed by alcohol or ether. Apply bands of Canton flannel to which are appended webbing straps.

3. To prepare a patient for transportation, the cord, weight and pulley must be removed and the webbing bands tied together over the lower end

FIG. 18.—Reversed Thomas splint. Note the ring encircling uninjured thigh and the flaring metal rod, supported by weight and pulley, connecting outer side-rod with ring.

of the Thomas splint. A six-inch stick of wood is placed over one band and under the other close to the end of the splint and twisted. The bands tighten. When sufficient traction is had, the end of the stick is allowed to rest against one or the other side-rod of the splint so that it may not unwind. This is the mechanical principle of an old friend, the Spanish windlass (Fig. 17).

This method of traction may be used at any time with a measure of success, in lieu of a weight and pulley, if one remembers to elevate the foot of the bed from six to twelve inches. The lower end of the Thomas splint, you will remember, is fixed to the cross-bar of the Balkan frame, and for the sake of comfort, it is necessary for the patient's body to slide towards the head of the bed in order that his perineum may be pulled away from the ring of the splint. But lying head-downwards is, in itself, not a pleasurable sensation. For this reason, and because automatically it takes up its own slack and preserves a constant tension, the weight and pulley system is preferable to the Spanish windlass.

4. We have provided vertical pull on the ring of the splint by a weight and pulley. From the ring a cord runs to the pulley on the longitudinal bar of the Balkan frame; from the distal end of the cord a weight is appended.

5. When there have been complicating wounds about the hip-joint we have preferred a reversed Thomas splint to a Hodgen. In the reversed Thomas splint, the ring encircles the sound thigh. The inner side-rod extends from the inner edge of this ring down the inner side of the injured thigh. The upper end of the outer side-rod is connected with the ring by a flaring semicircular rod of stout metal lying anterior to the groin (Fig. 18).

6. We have used an ordinary army bed, reinforced, on occasion, by slats between mattress and spring.

5. UNUNITED FRACTURES

Ununited fracture of the femur has seldom been encountered. Even with extensive loss of substance from a war injury, new bone tends to grow in relentlessly. With us, plates have been prohibited. Bone plates may sometimes be indicated, but I believe that they have seen their best days.

Old ununited fractures of the hip are effectively reconstructed by means of bone pegging. Through an anterior incision, or through an incision at the outer side of the tensor vaginæ femoris, expose the fractured surfaces and freshen them. Make a separate, short, vertical incision over the great trochanter. Drill through the trochanter into the head of the femur and drive in a six-inch peg. Close the wounds and immobilize in a plaster spica. Take a röntgenogram.

In every case of bone-grafting absolute immobilization of both fracture and graft is essential. The graft must be treated, not as a splint, but as a part of the fracture. In the presence of a compound fracture, which has developed a material sepsis, six months should elapse after wounds have entirely healed, before any tentatively clean open operation is attempted.

6. MALUNITED FRACTURES

Malunited fractures of the femur, on the other hand, have been common enough. Many of them we have detected early, while they were still plastic and were subject, therefore, to manipulation rather than to an open operation. Refracturing a femur is a simple and satisfactory procedure. One should observe these details:

1. Firm, bony union prevents successful manipulation. Extensive callus is likewise a contraindication. The callus may often be broken up, but it is impossible to get satisfactory alignment.

2. Protect the knee by encasing it in four padded boards—two lateral, one posterior, one anterior. The boards are held in place by an encircling bandage. The upper end of this board case is just below the level of the fracture, the lower end extends well down the leg.

3. Make one definite, complete movement in one direction only. Do not brutalize the site of fracture by excessive manipulation. Do not attempt to make the fracture loose; this is unnecessary. Hold the upper fragment and move the lower.

4. The direction in which this definite, complete movement is to be made depends on (*a*) the necessity of insuring that no bone spicule injures an important nerve or artery, and on (*b*) the arrangement of the fragments and of the callus at the site of fracture.

5. Apply traction immediately after refracture.

6. A refractured thigh must be kept in traction for from four to six weeks. A plaster spica or a walking Thomas may then be applied.

7. DOUBLE FRACTURES

Fracture of both femora has presented no unique difficulties. Thomas splints, applied on either side, interfere somewhat with the use of the bed-pan, but otherwise cause no great inconvenience. On the other hand, fractures of femur and tibia, on the same side, or of femur and adjoining patella, present a more serious problem. A complicating patella may well connote ultimate ankylosis of the knee-joint. One must anticipate, then, the position of choice for ankylosis. Personally, I favor ankylosis in slight flexion; some of our British contemporaries put the leg in complete extension.

A complicating tibia connotes double traction. Traction of the femur is carried out in accordance with accustomed methods. For a high tibial lesion, a moleskin extension, with its own weight and pulley, may be improvised. A low lesion of the tibia is very hard to hold. A bone plate may be needed. For extrinsic apparatus we have depended on the Sinclair skate or the Pearson calipers. The skate is not free from objections. It is apt to pull itself loose or the glue, with which it is affixed, is so apt to cause irritation that all treatment of the tibia may temporarily become impossible. Calipers behave much better. The points, bent to a more acute angle than for the femur, are placed on either side of the leg, about one and one-half inches above the tips of the malleoli, and made to penetrate the bone by tapping smartly with a hammer when the calipers are put in position.

8. COMPOUND FRACTURES

In war surgery nearly all our fractured femurs have been compound and very dirty at that. We have concerned ourselves with such problems as: 1. Adequate débridement. 2. Gas infection. 3. Complicating vessel and nerve injury. 4. Elimination of missiles. 5. The maintenance of thorough posterior drainage. 6. The detection of frequently recurring pus pockets in the muscle planes of the thigh. 7. The detection of metastatic joint infection—usually a streptococcus infection of the near-by knee-joint. 8. The removal, during convalescence, of sequestra.

In civil practice these dilemmas are rarely encountered and are not, therefore, within the scope of this paper. A few points are worth noting. The first is the possibility of retarding the extension of a septic process in an extremity by invoking the aid of gravity—by raising the head of the

bed, for example, to retard the extension of pus upward along the muscle planes of the thigh. A second is the advantage of maintaining immobilization with a Thomas splint during an operation on a fractured thigh. If operation is contemplated, one may replace the usual flannel gutter with two or more sterilized strips of aluminum or of sheet copper; unsterile portions of the splint are easily walled off with sterile towels. Again, we have learned that a metastatic, streptococcus infection of the knee-joint is often relatively innocuous if it is subjected to prompt, extensive lateral incisions. Such a joint in the presence of a fractured femur cannot, obviously, be mobilized. Sequestra we have eradicated by wide excavation, lightly packed to form a patent external wound. Gas infection is not to be expected in civil practice, so that amputation need concern us only in the event of destruction of the femoral vessels.

9. LATE TREATMENT

When union has become firm our patients have been given a walking Thomas splint, sometimes called a "walking caliper." Callus must be plentiful, properly placed and not tender on pressure. It must be homogeneous. How frequently a spongy callus occurs in civil practice I do not know; in war surgery with its prolonged sepsis it is not unusual to find a honeycombed callus that will stand little strain.

Pearson gives the following directions for measuring for a walking Thomas splint:

"A. Circumference of thigh at level of tuber ischii.

"B. Oblique circumference of thigh from tuber ischii on inner side to a point midway between the crest of the ilium and the tip of the great trochanter on the outer side. The difference between these two measurements is usually from 2 to 2½ inches.

"C. From tuber ischii to the sole of the heel."

The splint-maker adds half an inch to the last measurement to prevent weight-bearing on the patient's heel. Between the patient's heel and the leather surface on which ordinarily the heel rests, allow an air-space of half an inch. The splint-maker adds still a little more to the last measurement to allow for turning in of the ends under the boot-heel. A sliding adjustment permits revision if shrinkage occurs. The ring must fit snugly. The walking Thomas splint can be worn with advantage for from six to eight weeks. It may be taken off at night and several times during the day, in order to exercise the knee. In war work we have used the walking Thomas consistently. For patients in civil life it may not supplant a high heel (on the sound side) and crutches.

SUMMARY

Throughout this paper I have tried to focus my attention on patients in civil life. With this in mind, we have considered the anatomical deformities in fracture of the femur and the mechanics of correcting these

deformities. Remember that four particular deformities, which recur time and again, demand special watchfulness.

With the Thomas splint, however, these deformities may in great measure be overcome, because this splint supplies adequate support, fixation, extension, and counter-extension. If one uses this splint, fourteen fundamental points must be observed. Further points there are, varying with the particular technic that one adopts in connection with the application of the splint. The technic—the details of application—change with the taste of different surgeons. Of methods there are several, all of them depending on traction plus suspension, all of them sufficient unto the lesion in the hands of a skilful manipulator. Two of these methods have been described and illustrated in some detail: 1. The Pearson method; 2. the method used at Savenay.

Without much question the best type of traction is that with non-penetrating calipers. Pearson has evolved a technic which prescribes this type of traction and which allows for proper suspension. His method, therefore, or some modification of it, seems likely to come into general use.

We have considered, further, certain complications of fractured femur —ununited fractures, malunited fractures, double fractures, compound fractures. These issues have been considered briefly, because the problems of war surgery, in these exigencies, are rarely the problems of civil life. And, finally, a word has been said of late treatment, in so far as it relates to the walking Thomas splint.

This paper preaches the gospel of suspension and caliper extension for femur fracture. It attempts to describe the methods of employing the Thomas splint as the splint has been employed in the war clinics in France; it attempts to apply lessons learned in France to civil practice at home.

GENITO-URINARY SURGERY IN AN ARMY GENERAL HOSPITAL

By Walter A. Sherwood, M.D.

Lieut. Colonel, M.C., U.S.A., Chief of the Surgical Service, U.S. Army General Hospital No. 1.

and

William P. Herrick, M.D.

of New York

Captain, M.C., U.S.A., Urologist, U.S. Army General Hospital No. 1.

(From the Surgical Service of the U. S. Army General Hospital No. 1, Williamsbridge, New York)

The mass of genito-urinary work in the Army has undoubtedly been venereal. This demanded and produced standardized and better organized methods of treatment, as shown in the instructions and orders issued by the Surgeon-General's office as well as in the reports from some of our base hospitals and camps. In the work of an Army general hospital the number of these cases is more limited, so that the testimony of the larger camps and base hospitals is of paramount importance.

There is a considerable number and variety of urological cases, however, which present themselves in the course of general hospital work, the salient features of some of which, without the burden of too great detail, may prove of interest.

By far the most preponderant of these is some form of lithiasis of the genito-urinary tract (Figs. 1–5). The various types of infection of the kidney and bladder, including tuberculosis, together with new growths (Figs. 7–10), are encountered in their usual incidence, and the wounds of war have resulted in unprecedented opportunities for the study of the complications and sequelæ of traumatic lesions in all parts of the genito-urinary tract (Fig. 6). In all of these the X-ray, cystoscope, ureteral catheters and pyelogram have given us much valuable information and diagnostic help.

SPECIAL CASE REPORTS

Stone Impacted in Ureter (Fig. 3).—Surgical Comment: Although this stone remained in the ureter the patient was free from symptoms for a period of several months. He was later readmitted to the hospital with a return of pain and bloody urine. Dilatation of the ureteral orifice and repeated injection of oil were then successful in dislodging the stone, which escaped into the bladder and was later passed through the urethra.

Although this patient was anxious for radical relief, operation was not advised because of the position of the stone and the difficulties often experienced in attacking this part of the ureteral canal (about 2 cm. above the cysto-ureteral valve).

Multiple Calculi Impacted Near Lower End of Ureter (Fig. 4).—Surgical Comment: The calculi were removed by an extraperitoneal ureterotomy. All symptoms dis-

appeared after this operation. In contrast to the previous case, radical operation was imperative because of interference with kidney function, the multiplicity of stones and almost certain failure of palliative measures and intravesical manipulation.

Gunshot Wound of Bladder (Fig. 6).—This figure shows a catheter coiled up in the suppurating cavity of a gunshot wound communicating with the bladder. The catheter was passed through a sinus which had its origin external and posterior to the left great trochanter. Urine escaped copiously from this wound and a traumatic stricture completely occluded the urethra. Suprapubic cystotomy, combined with external urethrotomy and retrograde dilatation of the urethra from above, succeeded in restoring the urinary canal. Both suprapubic and perineal drainage were continued until the sinus had healed, after which the regular and persistent use of sounds kept the urethra open. The patient now passes all urine in a normal manner, but as the bladder was badly damaged, that organ remains permanently contracted.

Tuberculosis of Kidney (Figs. 7 and 8).—Surgical Comment: Diagnosis verified by presence of tubercle bacilli in urine and positive autopsy findings in an injected guinea-pig. Nephrectomy and good recovery. Fig. 7, a skiagraph of the kidney after removal, shows shadow of tuberculous cavity. Fig. 8 is a photograph of the sectioned kidney after removal. Necrotic cavity well shown (same patient)

Papillomatous Carcinoma Entirely Filling the Pelvis of the Kidney (Fig. 9).—Surgical Comment: This patient, a major in the Medical Corps, aged 59 years, had been well until June 12, 1918. At this time he was on active duty at San Juan, Porto Rico. He suddenly became ill with chills and a high fever. A septic temperature continued and he emaciated rapidly. He was returned to this country and admitted to U. S. A. General Hospital No. 1 on July 15. The patient was extremely ill and a large retroperitoneal tumor was found on the right side. *Urine* showed hyaline and granular casts, much albumin and many leucocytes. *Blood*—Red cells, 4,500,000; hæmoglobin, 42 per cent.; white cells, 15,800; polys, 81 per cent. Cystoscopy and attempts at ureteral catherization demonstrated complete occlusion of the ureter on the affected side.

July 17: Operation by Lieutenant Colonel Sherwood. Large cystic tumor found involving the entire substance of the right kidney. The tumor was freely incised through a lumbar incision and at least a quart of thick brownish pus was evacuated. No stone found, but the entire substance of the kidney was converted into a large abscess cavity. The patient's condition did not permit of anything more radical, and free drainage was established. The wound drained copiously and great improvement followed.

August 13: Cystoscopy. Bladder normal. No urine issuing from right ureteral orifice, but clear urine appeared on the left side.

August 20: Functional kidney test with phenolsulphonephthalein, first hour, 53.5 per cent.; second hour, 10 per cent.; total, 63.5 per cent.

August 26, 1918: Operation by Lieutenant Colonel Sherwood. Wound reopened through previous lumbar incision and kidney found to be much enlarged and adherent in every direction. Involving the upper three inches of the ureter was a thick friable exudate. The pedicle was short. Large abscess cavity at upper pole and two smaller cavities at lower pole. Kidney delivered and removed, after satisfactory ligation of pedicle. It was now seen that a new growth involved the entire kidney pelvis and the first three inches of the ureter, which was ligated as low as possible and excised. Wound closed in usual manner with drainage. Subsequent operation for lumbar hernia.

This patient has made an excellent recovery up to this time and has regained sixty pounds in weight. The specimen herewith shown by photograph (Figs. 9 and 10) is a unique one and is permanently preserved in the Army Medical Museum at Washington.

Urinary Fistula Following Gunshot Wound of Ureter.—Soldier wounded September 7, 1918, at Château-Thierry in right lumbar region at level of fourth lumbar vertebra, two inches to the right of the median line. Urine escaped freely from the wound on the second day after the injury. One week later had intense pain in the

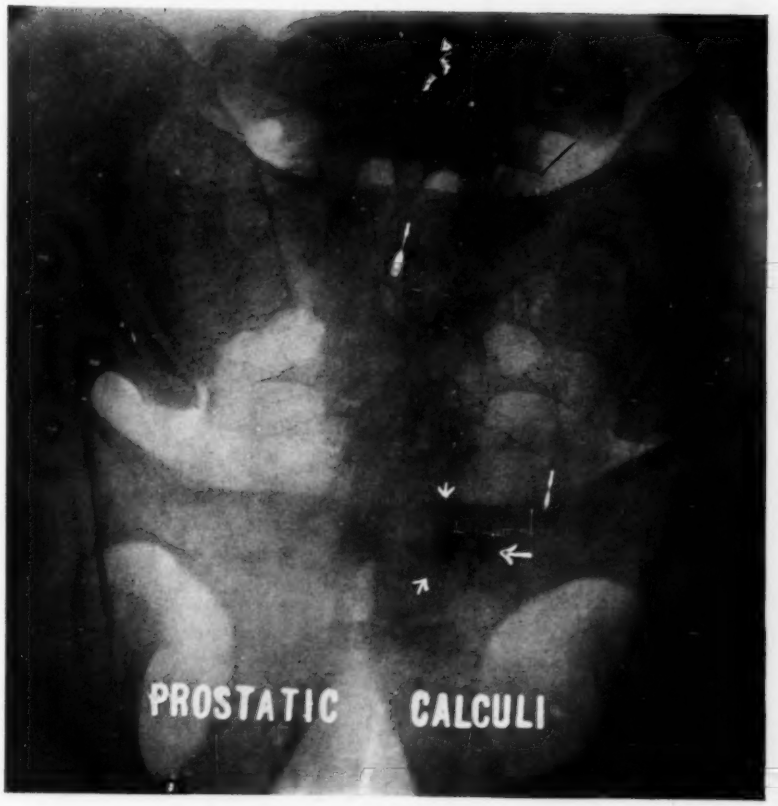


FIG. 1.—Calculi imbedded in prostate gland.

FIG. 2.—Vesical calculus.

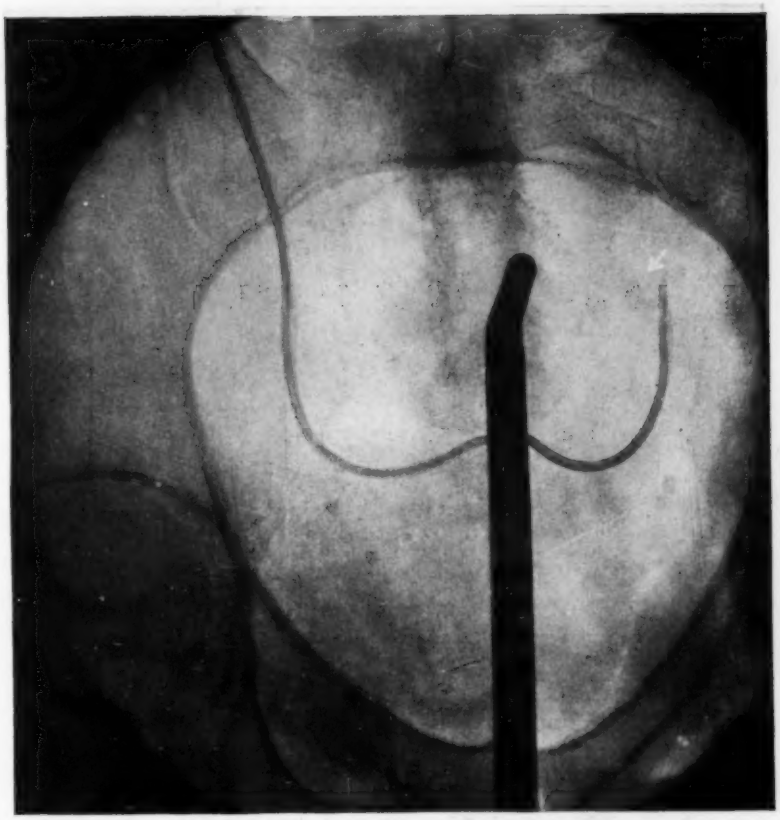


FIG. 3.—Calculus in ureter. Cystoscope in place in bladder; skiagraph shows ureteral catheter impinging upon the calculus in the right ureter. (See Special Comment.) Three c.c. of sterile cottonseed oil were injected into the ureter beyond the stone, bringing the calculus 2 cm. lower in the canal.

FIG. 4.—Multiple (7) calculi impacted near the lower end of the ureter.

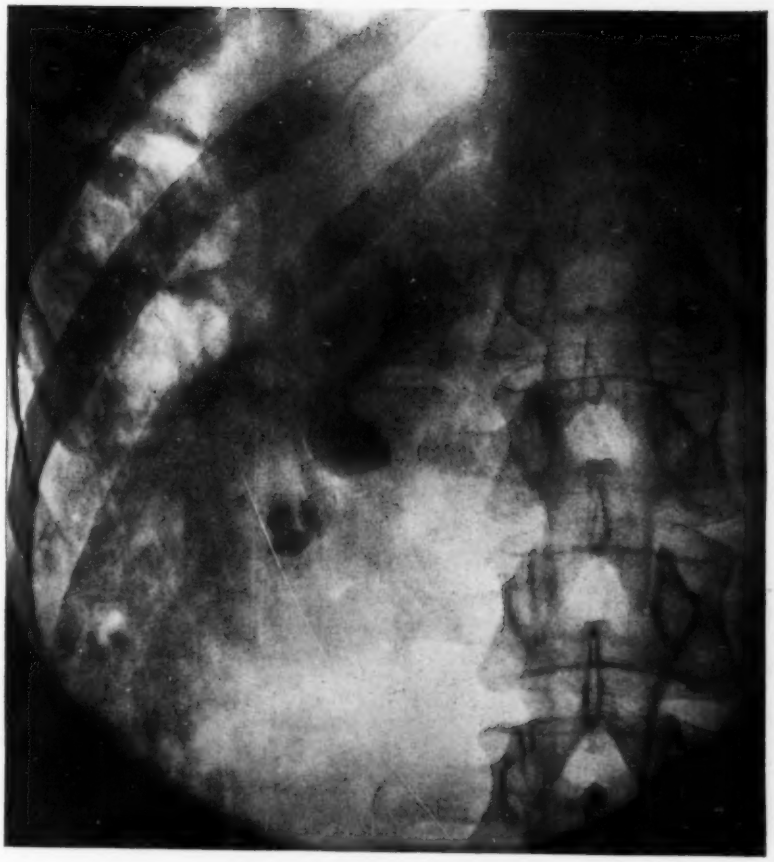


FIG. 5.—Renal calculus.

FIG. 6.—Gunshot wound of bladder; catheter passed through a sinus opening superficially external and posterior to the left great trochanter.

FIG. 7.—Tuberculosis of kidney. X-ray of kidney after removal

FIG. 8.—Tuberculosis of kidney. Specimen shown in Fig. 7 sectioned. Necrotic cavity well shown.

FIG. 9.—Papillomatous carcinoma of kidney.

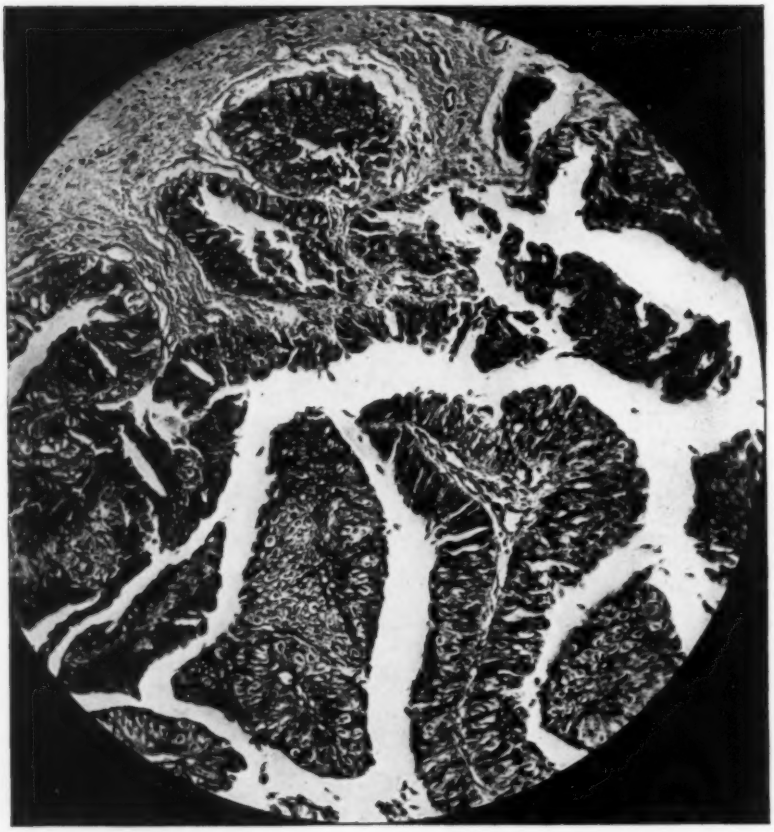


FIG. 10.—Papillomatous carcinoma of kidney; microscopic section of growth shown in Fig. 9.

left inguinal region: this area was incised and pus mixed with urine was evacuated. On January 1, 1919, he was sufficiently recovered to be returned to this country, and when admitted to U. S. Army General Hospital No. 1 examination revealed an operative scar in the left lower abdominal quadrant. In this scar were the openings of two sinuses, both discharging pus and watery fluid resembling urine, and later proved to be such by the oral administration of methylene blue. A probe passed into the upper sinus led upward and backward toward the flare of the ilium; the lower sinus passed downward and inward toward the bladder. The sinus in the right lumbar region discharged urine and pus intermittently.

The bladder was injected with 10 per cent. thorium solution. X-ray showed bladder asymmetrically filled, a defect appearing on the left side. X-ray of the back showed destruction of a portion of the body of the fifth lumbar vertebra. Probes in the sinuses demonstrated that one passed upward retroperitoneally and the other passed downward into a pelvic pocket.

Cystoscopic Examination.—Right ureter catheterized and catheter passed for a distance of 31 cm. without obstruction. Secretion of urine clear and normal in amount. One c.c. of phenolsulphonephthalein injected intravenously showed color in four minutes from right ureter. Specimen of first fifteen minutes, 26.75 per cent.; second fifteen minutes, 7.84 per cent.; total, 34.59 per cent. Catheter passed 21 cm. into left ureter, and there met definite obstruction. No urine obtained. Sterile water injected through this catheter was recovered from left abdominal sinus.

Conclusions.—Bladder uninjured. Right ureter intact and right kidney normal and has good function. Left ureter divided 21 cm. from bladder, and urine from left kidney being excreted through left abdominal and right lumbar sinuses.

April 22, 1919.—Operation by Lieutenant Colonel Sherwood. Left nephrectomy. Considerable difficulty experienced in separating atrophic kidney from surrounding adhesions. Ureter found to have been shot away from the kidney just below the renal pelvis. Kidney removed in usual manner and wound closed with drainage. Convalescence was uneventful. Sinuses healed promptly and patient is now entirely well.

Double Ureteral Obstruction. Anuria-Uræmia.—Private H., wounded Oct. 2, 1918, by high explosive shell, causing comminuted compound fracture of the left femur. Wound not completely healed in March, 1919, when he noticed pain in right side radiating to the testicle. Hæmaturia was present and some sand-like substance was passed. Admitted to U. S. A. General Hospital No. 1, March 24, 1919, with severe pain in both kidney regions, chilly sensations and nausea. X-ray showed bilateral ureteral calculus and right hydronephrosis. Cystoscopic examination and ureteral catheter demonstrated complete obstruction of right ureter.

March 26: Patient became rapidly uræmic. Œdema of face and eyelids, partial stupor, impaired vision (10/100), but no retinitis. Anuria. Operation by Lieutenant Colonel Sherwood. Right nephrotomy. No stone in kidney pelvis. Organ greatly enlarged. Ureter isolated and found completely obstructed for a distance of one and a half inches with fine sand-like material. Ureter incised and obstructing material removed with forceps until probe passed freely into the bladder. Ureteral wound left open, kidney sutured and wound closed, with drainage.

There was immediate improvement in the patient's condition. An ample amount of urine was passed and uræmic symptoms subsided until April 4, when, in spite of free drainage from the right kidney, he ceased voiding, and had severe pain in the left lumbar region, with return of nausea and facial œdema. X-ray showed the same condition in the left ureter. Operation April 7, and obstructing mass found three inches below the kidney pelvis. Ureter incised, sand-like material and small calculi removed, and ureteral catheter passed first into the bladder and then into the pelvis of the kidney from which turbid urine escaped. Kidney enlarged to three times its normal size, but no stone was found. Wound in ureter left open, with rubber tube and cigarette drain.

From this time the patient made a prompt and satisfactory recovery. Urine passed freely and both wounds are completely healed.

The above presentation, although incomplete and desultory, represents the general scope and character of genito-urinary surgery as seen in Army general hospitals. These cases well illustrate the necessity of closest coöperation between the cystoscopist, the X-day department, and the general surgeon. We are particularly indebted to the X-ray laboratory for their enthusiastic efforts in interpretations which established many diagnoses, which would otherwise have remained in doubt.

SALVAGE OF THE HAND BY TIMELY REPARATIVE SURGERY *

By John B. Roberts, M.D.
of Philadelphia, Pa.
Professor of Surgery University of Pennsylvania Graduate School of Medicine

The human hand has often in the past been denied the benefits of wise early treatment and the help of the reconstructive surgery now so effectively applied to other regions. This surgical neglect has arisen from two chief causes. Many patients with injuries of the structures concerned in finger movements are sent for treatment to hospitals, in which such hurts meet only the eyes of a tyro in surgery. This surgical interne realizes that walking patients are not of great interest to the experienced surgeon, that the damaged hand will probably not be given treatment in the hospital wards, nor if admitted to the ward will they be kept in bed. Hence he considers himself justified in assuming full care of the injury. Foot wounds are much more likely to be seen by a surgical chief and be well treated than are manual mutilations. An exception to this statement is justified when these hurts occur in manufacturing plants having a well organized surgical service with a wide-awake and well paid up-to-date surgical chief.

A second cause of inefficient management of crippling wounds of the wrist and hand is delay on the part of even skillful operators to give attention to new developments in surgical art. They think they "know it all." On the other hand, men who admittedly have had but moderate surgical experience and who are therefore of unripe judgment show an unwillingness to serve as dispensary or out-patient surgeons. Their chief desire is to rush into what may be termed capital or major surgery. They need to be taught by their official medical superiors that the out-patient service gives opportunity for surgical practice of the highest professional quality if combined with earnest and thoughtful intelligence, careful records, accurate treatment and a systematic search for end results.

One need only think of the innumerable misshaped and crippled hands and forearms due to unreduced and badly treated fractures of the lower end of the radius to appreciate the truthfulness of my statements. The unfortunate deformities not infrequently seen in men who have been treated, by the average surgeon, for fractures of the mandible are corroborative evidence of a similar lack of professional acumen in another field of reconstructive surgery.

The professional services rendered in accident wards and dispensaries to ambulant patients entrusted to unfit doctors have long been criticized by those who are familiar with existing conditions. It has been as difficult to get the medical and administrative officers of such hospitals to

* Read before the American Surgical Association, June 17, 1919.

wake up to this evil as it was formerly to convince them that anæsthesia perils to the lives of confiding patients were a disgrace. At the present time, not a few hospitals need a change in their methods of handling so-called minor surgical lesions of the hand and finger. It is not my intention on this occasion, to dwell upon the measures by means of which the care of such hand wounds may be improved; nor do I wish to detail the therapeutic indications, the operative procedures, or the mechanical aids now offered by surgery for prevention or relief of special manual disablements.

It, however, is my hope to arouse in the minds of us who are surgeons and those who manage hospitals a recognition of the necessity for a united voice demanding that men who are hurt shall not be deprived of industrial usefulness by reason of professional ignorance or indifferent surgical care.

Let me, even at the risk of making my paper seem like a catalogue, bring to your minds some well-known conditions liable to meet with inefficient management, when entrusted to busy or uninformed or careless surgical practitioners.

Think of the lack of instruction on intelligent asepsis in many first aid dressing rooms; attempt to estimate the degree of unnecessary suffering from infected fluids under tension; remember the delay in giving pus exit because of insufficient incisions, or continued plugging with dry dressings, or with ridiculous corks of supposed drainage material; watch the spreading lymphangitis and the occurrence of distant lymphadenitis because motion of forearm and hand has not been prevented by proper splints; observe the rise in bodily temperature due to confined septic exudates and the gradual sloughing of edges of sutured lacerated tissues which should have been cut away or left unstitched until closure was reasonably permissible; remember the damage possible to happen to tendons, nerves and joints from incisions for treating paronychia at the hands of unskilled operators; calculate, if you can, the value of digital deftness lost by a half dozen badly treated palmar abscesses; think of the number of unnecessary amputations of fingers and portions of hands which may take place in any large metropolitan hospital in one year.

Some of these surgical misdemeanors result from limited clinical experience; others are due to an over development of operative zeal. To be a surgeon is supposed by not a few beginners in our art to entail necessarily the abundant shedding of blood. This defective definition may urge a too hasty resort to the scalpel. There are, however, instances also of deficient examination of patients to which the blame may be attached. Crippled hands, too, may be the result of aseptic closure of wounds at or above the wrist being done without the operator seeing that tenosuture or even nerve suture or stitching of divided muscular bellies may be demanded by the severity of the injury.

Crushing and extensively lacerated wounds from machinery, destruc-

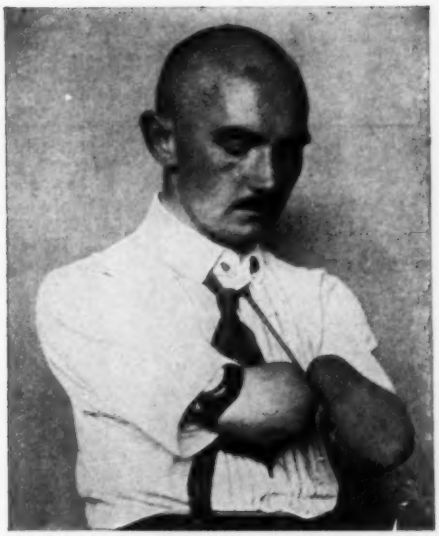


FIG. 1.—A teacher, both of whose hands had been amputated when six years old. He had learned to be absolutely independent and had passed his examination entitling him to a teacher's license. Without artificial limbs he could dress himself (the illustration shows him in the act of buttoning his collar), shave, eat with grace and assurance, write an unusually legible hand with more than normal rapidity, travel long distances alone, carry a suit case and pay his fares, just as the normal individual would. All this was done by careful education of the stump, which in his case had acquired almost the same sensitiveness as the tips of the fingers.

FIG. 2.—Judge Corley's apparatus for helping the man who has lost both hands to button his collar.

FIGS. 3 and 4.—Extension of fingers enabling patient to play piano, and full flexion in making a fist; due to plastic reconstruction of deformed hand in youth to relieve hyperextension of fourth and fifth fingers, caused by burn on back of wrist and hand.

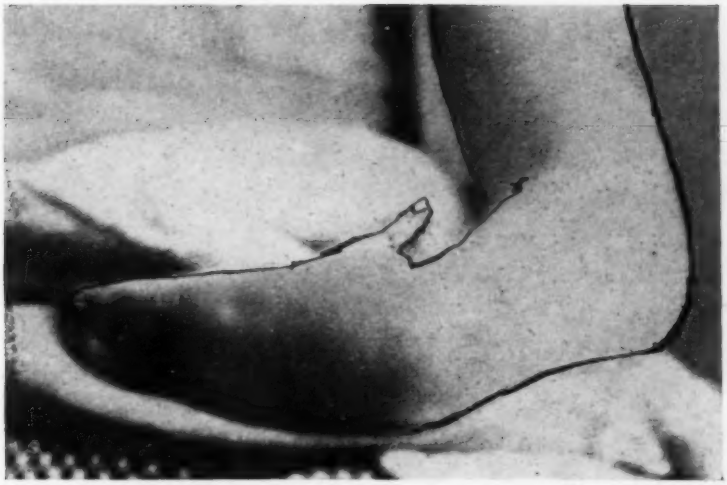


FIG. 5.—Thumb, five months after repair by cutaneous transfer from thigh.

FIG. 6.—Showing relief of extreme hyperextension of thumb after burns of forearm and palm. Hand needs further reconstruction, though the change in angle of thumb by previous operations has been about 180 per cent.

FIG. 7.—A Reconstruction Aide freeing a scar from the bone by massage. Weeks of patient endeavor are finally rewarded by motion and strength returning to the useless wrist and fingers.

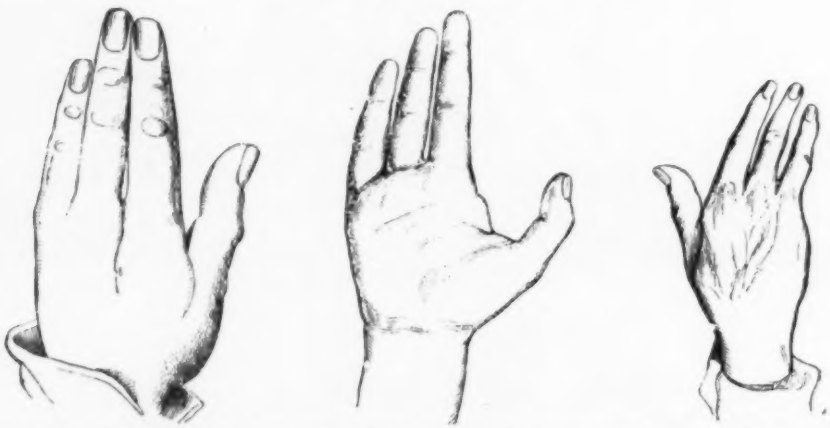
FIG. 8.—Solving a knotty problem.

FIG. 9.—The Keller artificial hand. The picture illustrates Keller's method of inserting a small knife, with which he is sharpening his pencil. Note also the piece of cork attached to the pencil. This enables him to grip the pencil between the claws and to write with it. The lower arm socket is held firmly in place by a broad strap which makes a figure-of-eight turn about the elbow.

FIG. 10.—One-armed bracemaker's apprentice's method of gripping the hammer between the stump, upper arm and chest.

FIG. 11.—Tunnel flap for subcutaneous transfer of tissue of thigh to repair thumb. (Keen's Surgery, after Haubold.)

FIG. 12.—Lacerated thumb after subcutaneous transfer of integument. Ultimate result about five months after original operation.



FIGS. 13, 14 and 15.—Results of amputation above metacarpo-phalangeal articulation in middle, index, and ring fingers.

tion of soft parts by burning, and damage arising from gunshot fractures are especially liable to unwise surgical treatment. The determination of what should be deemed non-viable and at once removed is not always easy. Inexperience in averting infection of contaminated wounds may induce unnecessary operative mutilation. So also unfamiliarity with recent developments of plastic reconstruction with pediculated flaps, bridge flaps, transplants of skin, bone and tendon may influence the selection of primary amputation, when delay would give opportunity for successful secondary patching of palm or dorsum, readjustment of bony fragments, transfer of muscular attachments and perhaps even arthroplasty.

It is very probable that many surgeons do not yet sufficiently recognize the invaluable assistance obtainable through baking, hot water soaking, and efficiently regulated massage in rigidity of fingers from inflammatory exudates and the fibrous transformation of granulation tissue. Cavities and gaps to be repaired, after gangrene, should seldom be permitted to close up by means of the slow fibrous contraction of granulations. It is usually wiser to promptly obtain a sterile, or relatively sterile, surface and substitute for the missing structures a transplant or flap of integument, adipose tissue, fascia, bone or nerve. Much deformity may be due to long waiting for healing through fibrous transformation in secondary repairs. The contractile power of fibroid change in granulation tissue of wounds has been shown by Carrel and other experimenters to occur to a degree almost beyond belief. Fibrous tissue healing of deep wounds or after extensive loss of substance in the hand may be a wary and unrecognized enemy of the surgeon. Finger joints become locked in disabling ankylosis or are by a slowly increasing change in axis caused to undergo secondary dislocation. These distortions are sometimes so slow in reaching their maximum that their possibility is not sufficiently anticipated by the surgeon. He may be startled months after a patient has been discharged from treatment by having a deformed hand presented to him for explanation in a suit for malpractice.

Burns of a necrotizing degree are particularly liable to produce these manual disabilities. I have operated with final success on a number of such cases in children. Using skin and subcutaneous fascia in pediculated flaps from forearm or neighboring parts of the hand, or supplying the needed tissue by stitching the hand to the abdomen from which a flap with pedicle has been lifted have been very satisfactory. It is often necessary to do a series of operations. The scar tissue usually must be dissected away quite freely before the flap of normal tissue is sewed in the gap. The distortion should be relieved fully by the dissection before the flap is inserted. Aseptic operations and asepsis during the healing are of great value in hastening the restoration of function. Septic complications, although very undesirable, fortunately do not always bring complete failure. Each operative effort in the series may gain something. Massage, hot water bathing and baking carried out for weeks

may complete an imperfectly obtained operative reconstruction. Free flaps, or grafts, seldom give results, however, unless the operation and after-treatment reach a degree of sterility that is almost perfect.

Much may be done to relieve the deformities due to anæmic myositis, often called Volkmann's contracture, if the surgeon recognizes early the beginnings of this neuromyositic change occurring from undue pressure of bandage or splint upon the muscles and nerves of the arm. The appearance of trophic changes in the finger-nails and a slight spastic rigidity of a group of muscles should at once arouse suspicion of what is happening. Relief of pressure must be instantaneous; and massage, hot water soaking and splint or elastic traction be used to give aid to the relatively weak muscles. Long continued treatment of this kind aided by electric stimulation, may avert and even correct grave manual disability of the fingers from fibroid alteration of the affected muscular bellies and fibroid changes in the joints. Old cases may be improved by transfer or elongation of tendons, and other orthopædic devices; but I am speaking now of the advantages of an early and alert institution of what may be termed physiologic therapy.

Industrial and military injuries give many chances for saving damaged fingers by using plastic procedures. Hence, such wounds should not be entrusted to those uninitiated in reconstruction of soft tissues. Even the skeleton of the carpus, metacarpus and phalanges may be susceptible of osteoplastic reconstruction. A thumb with a movable little finger is better for a mechanic than the most beautiful artificial hand. So also is there greater efficiency possible from a mere stump of the thumb with such parts of the other fingers as will give the man a grasp. Excision of metacarpal bones may convert a badly shot or crushed hand into a member looking like a crab's claw, but even that gives a better wage-earning tool than an expensive imitation of the human hand.

Amputation of fingers merely stripped of integument has often occurred at the hands of would-be surgeons, although pedunculated flaps from abdomen or thigh would have furnished a new covering for the marvellously competent tendons left uninjured by the accident.

Tendon grafting, nerve grafting or nerve suture, transfer of muscular insertions, and carefully planned substitution of new bony segments to the skeleton of the hand come to mind as useful expedients to be ever kept in mind by surgical attendants upon industrial workers or soldiers who have received disabling wounds of the upper extremity. These expedients are applicable to old as well as recent injuries; but the golden opportunity is usually at the time of accident. It is possible to use a toe grafted on the hand as a substitute for a thumb.

Congenital deformities of forearm and hand are susceptible of great relief by plastic operations. Plastic flaps, skin grafting, bone grafting and similar procedures have been utilized in recent years to an extent which was unanticipated a few decades ago. Asepsis, anatomic knowl-

edge and artistic reconstructive surgery form the tripod upon which successful work depends.

Surgeons should remember that mere amputation requires little operative skill. It may be an opprobrium of surgery. The question should be how much more valuable to the patient will be an efficient semblance of a hand of bone, muscle and nerve than the most beautifully modeled mechanical substitute with little functional ability. He must not forget that spastic muscular contraction or scar rigidity may cause an almost irremedial distortion or prevent the adjustment of an artificial hand. Early efforts of the patient to train the residual tissues left by the operator must be demanded. Such aid as exists in heat, massage and orthopædic expedients must be furnished the crippled man.

His mental attitude toward deformity must be modified by insistence that good looks are less valuable than good works. Sentimental timidity of the patient has no place in reconstructive surgery of the hand. He must be urged and driven to train his remaining fingers, his stump or his forearm and arm muscles to develop manual facility. The surgeon must not think his responsibility ceases with healing of operative or preoperative wounds. Contraction in flexor muscles is more likely to occur than in the extensor group. This should be averted by active and passive mobility begun promptly. In amputation through the forearm and even in the arm, all joints and muscular masses possible should be saved, because artificial hands can often be made valuable by using muscles in the stumps to pull on springs moving the mechanical fingers. The elbow-joint is a very necessary adjunct to an efficient artificial hand. A stump below that joint and even a muscular mass remaining below the shoulder-joint may be utilized to give motion to the prosthetic hand.

Instruction in moving the muscles left in a stump will often enable plastic secondary operations to give the patient a kinetic hand, otherwise impossible. Leo Mayer has well stated this fact. (*International Clinics*, 1918, vol. iv, p. 200.)

Sauerbruch, Ceci and Vanghetti have done valuable work in this direction. Fellows of this Association who have seen military service can probably teach much in salvage and orthopædic development of injured hands. Modification of badly created stumps may be required. Wise selection of substitutes for the hand will often need expert advice from men with trained mechanical experience.

It will be admitted that few deformities congenital or acquired exceed in importance those which destroy conventional use of the hands. Total or partial inability to clothe or feed oneself or to minister to one's own necessities or amusements usually creates at first a state of mind and a poverty of happiness which must be remedied. Whether the disability be great or little, the educational side of the compensatory training is not to be forgotten. The patient must be taught that even the loss of both

hands does not create a helpless invalid; and that a partial loss only of one or both hands constitutes a very valuable asset in his after history.

Prosthetic appliances are of very little value when first installed. Consideration of the mental equipment and the needs created by the deformity must be joined with a wise selection of an appliance which will permit requisite mobilization of the structures retained in the hand or those to be provided by a mechanical substitute. Very simple appliances will permit a man to perform many kinds of manual work after amputation of the entire hand. P. H. Knight in the March number of *Carry On* shows pictures of a man who lost both hands by amputation through the forearms. By means of extensions of the forearms and attached wrist plates, to which hooks and other implements are fixed by means of a spring catch, he can dress himself in about a half hour, shave himself and even button his collar and tie his shoes. He writes, uses the telephone and for more than twelve years has earned "good living wages" in a manufacturing company. Such ability gained at the adult age after bilateral amputation of the hands rivals that which is seen in the use of toes instead of fingers in persons born without hands or arms.

A number of hands have been devised which have the appearance of the natural members. It is possible to secure mobility of wrist and fingers and rotation of the hand in some of these artificial hands. By using hooks, braces, springs, levers and the stumps of muscles, even if these muscles are far from the substitute for the hand, nearly all amputation cases can be helped. Some artificial hands obtain movement of fingers through levers which secure motion from muscular action near the elbow-joint or from the region near the shoulder. It may be necessary in some patients to make a shoulder or other joint rigid, or perhaps to create a false joint by arthroplasty. Constant training of the muscles and insistence upon the remedial character of the patient's deformity will in time develop a remarkable degree of manual ability.

To Contributors and Subscribers:

All contributions for Publication, Books for Review, and Exchanges should be sent to the Editorial Office, 145 Gates Ave., Brooklyn, N. Y.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS *of* SURGERY
227-231 S. 6th Street
Philadelphia, Penna.